6-0-66

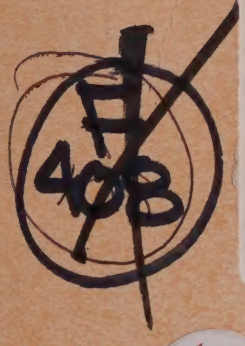
STRUCTION MANUAL

File Singer

**Panoramic***

SPECTRUM ANALYZER

MODEL SPA-10



PANORAMIC
MARKETING
FILE COPY

Gertsch*
EMPIRE*
Sensitive Research*
Panoramic*

SINGER

*A Trademark of THE SINGER COMPANY

*Precision electrical and electronic instruments for measurement*

THE SINGER COMPANY • METRICS DIVISION

# INSTRUCTION MANUAL

## Panoramic*

SPECTRUM ANALYZER

MODEL SPA-10

Gertsch*

EMPIRE*

Sensitive Research*

Panoramic*

SINGER

*A Trademark of THE SINGER COMPANY

*Precision electrical and electronic instruments for measurement*

THE SINGER COMPANY • METRICS DIVISION

# WARRANTY

THE SINGER COMPANY, METRICS DIVISION, warrants each new instrument to be free from defects in material and workmanship, effective after delivery to the original purchaser as follows:

*Commander** Instruments: Potentiometers, Bridges,
Volt Ratio Boxes and Standard Resistors.....5 years
*Sensitive Research** Electrical Indicating Instruments.....2 years
Other Electrical and Electronic Measuring Instruments.....1 year

Repair or replacement (at our option) without charge (F.O.B. factory) will be effected when our examination satisfactorily indicates that defects are due to workmanship or materials. Electron tubes, semiconductors, batteries, fuzes, lamps, thermoelements, and *RatioTran** potentiometers are excluded from warranty coverage. Warranty returns must first be authorized by the factory.

If the instrument or any portion thereof, has been abused, misused, damaged by accident or negligence, or if any serial number or seal has been removed or altered, the warranty is void.

This warranty is in lieu of all other obligations or liabilities expressed or implied and The Singer Company neither assumes, nor authorizes any person to assume for them, any other liability in connection with sales of instruments manufactured by The Singer Company, Metrics Division.

**THE SINGER COMPANY • METRICS DIVISION**
915 PEMBROKE STREET, BRIDGEPORT, CONNECTICUT • 3211 S. LA CIENEGA BLVD., LOS ANGELES, CALIFORNIA

*A Trademark of THE SINGER COMPANY

## REPAIR AND MAINTENANCE

Instruments should be returned only on prior written authorization from the Singer Representative or the factory(1). Warranty repair will be made upon written request. Please provide the following information in order to expedite our processing of your instrument:

1. Model or Type
2. Serial Number
3. Description of trouble(2)
4. Test instruments used
5. Approximate date instrument was placed in operation
6. Approximate number of hours of use
7. Has maintenance action been previously requested?
8. Other comments

Upon receipt of this information our Service Department will send you service data or shipping instructions. Upon receipt of shipping instructions forward the instrument to the factory prepaid. If requested, an estimate of charges will be made before work begins.

(1) Contact Metrics Division, Bridgeport, Connecticut for *Commander**, *Empire**, *Panoramic**, and *Sensitive Research** instruments. Contact Metrics Division, Los Angeles, California for *Gertsch** instruments.

(2) Include data on symptoms, measurements taken, suspected location of trouble, maintenance action taken, and any other relevant data.

WARD/DAVIS ASSOCI...S
757 E. Evelyn Ave.
Sunnyvale, Calif. 94086
(408) 245-3700

TABLE OF CONTENTS

CHAPTER I - INTRODUCTION PAGE

I-1. General ..... 1

I-2. Applications ..... 1

I-3. Equipment Supplied ..... 2

I-4. General Description ..... 3

I-5. Electrical Characteristics ..... 5

I-6. Physical Characteristics ..... 8

I-7. Tube Complement ..... 8

I-8. Front-Panel Controls ..... 13

I-9. Terms and Definitions ..... 20

CHAPTER II - INSTALLATION

II-1. Initial Inspection ..... 23

II-2. Interconnecting Procedure ..... 24

II-3. Installation Adjustments and Checks for Indicator Unit ..... 24

II-4. Installation Adjustments and Checks for Tuning Head ..... 36

CHAPTER III - OPERATION

III-1. General Operation ..... 42

III-2. Frequency Determination ..... 45

III-3. Amplitude Measurements ..... 56

III-4. Narrow Band Analysis ..... 65

III-5. Interpretation of Various Spectras ..... 67

III-6. Typical Test Applications ..... 69

## LIST OF ILLUSTRATIONS

CHAPTER I - INTRODUCTION


| Figure | Title | Page |
|---|---|---|
| I-1 | Spectrum Analyzer SPA-10 Front Panel | A1 |
| I-2 | Bandwidth Versus Sweep Width | A2 |


CHAPTER II - INSTALLATION


| | | |
|---|---|---|
| II-1 | Outline Dimensional Drawing, Model SPA-10 in cabinet | A3 |
| II-2 | Outline Dimensional Drawing, Model SPA-10 with Mounting Rack and Tray | A4 |
| II-3 | Model SPA-10 Slide Rackmount | A5 |
| II-4 | Screen Presentation for 30 cps Sweep Rate | A6 |
| II-5 | Expanded Pip Display | A6 |
| II-6 | Optimum Resolution | A7 |
| II-7 | Sensitivity Measurements | A7 |


CHAPTER III - OPERATION


| | | |
|---|---|---|
| III-1 | Correct Viewing of CRT Screen | A8 |
| III-2 | Spectrum of .01 Microsecond Pulse | A9 |
| III-3 | Test Setup for Wavemeter Measurements | A10 |
| III-4 | Typical IF Flatness Curve | A11 |
| III-5 | Resolution of Interfering Signals | A12 |
| III-6 | Ringing as an Indication of Optimum Resolution | A12 |
| III-7 | Separation of Closely Spaced Signals | A13 |
| III-8 | Resolution of Signals of Unequal Amplitude | A13 |

LIST OF ILLUSTRATIONS

(Cont.)


| Figure | Title | Page |
|---|---|---|
| III-9 | Spectrum of Incidental FM | A14 |
| III-10 | Video Filter Effects | A14 |
| III-11 | Correct Use of INTENSIFIER Control | A15 |
| III-12 | Amplitude Modulated Signal | A15 |
| III-13 | Spectrum of Balanced Modulation | A16 |
| III-14 | Spectra of FM Modulated Signals | A16 |
| III-15 | Spectrum of Pulse-Modulated Wave Comparing Fast and Slow Sweep Speeds | A17 |
| III-16 | Insertion Loss Test Setup "a" | A18 |
| III-17 | Insertion Loss Test Setup "b" | A19 |
| III-18 | VSWR Test Setup | A20 |
| III-19 | VSWR Response | A21 |
| III-20 | Test Setup for Wavemeter Calibration | A22 |
| III-21 | Visual Frequency Comparison Test Setup | A23 |
| III-22 | Filter Response | A24 |
| III-23 | Test Setup for Filter Response | A25 |
| III-24 | Screen Presentation Showing Microphonic Effects | A26 |
| III-25 | Transmitter Output Measurement Setup | A27 |
| III-26 | Typical CRT Indications | A28 |

# CHAPTER I - INTRODUCTION

## I-1. GENERAL

This instruction manual has been prepared to assist in the installation, operation, and maintenance of the Panoramic Spectrum Analyzer, Model SPA-10.

No attempt to operate the equipment should be made until the operator is thoroughly familiar with the operation instructions contained in Chapter 3.

## I-2. APPLICATIONS

Inquiries are invited regarding special applications of this equipment to particular requirements. The following list represents but a few of the many possible applications of the Panoramic Spectrum Analyzer, Model SPA-10.

Visual examination of oscillator or transmitter performance.

Monitoring communications channels and radar frequencies.

Analyzing pulsed signals.

Analysis of spectra associated with AM, FM, and PM signals.

Direct reading of power points and nulls.

Studies of malfunctions in microwave equipment such as spurious signals, instabilities, and microphonic effects.

Noise spectrum studies.

Harmonic and other out of band measurements.

Examination of CW signals for frequency drift, incidental FM, and squegging.

Examination of dynamic operating characteristics of microwave tubes.

Checking for r-f leakage and radiation.

Determining presence and frequency of r-f signals.

As a sensitive receiver to measure characteristics of microwave components or circuits such as insertion loss measurements and VSWR measurements.

## I-3. EQUIPMENT SUPPLIED

The following units constitute a complete set:

| Description | Quantity per Equipment |
|---|---|
| Panoramic Microwave Spectrum Analyzer, Model SPA-10 | 1 |
| Accessory Kit #556019-172 | 1 |

Table I-1 lists the Accessory Kit complement.

Table I-1. Accessory Kit Complement

| Consists of | Singer-Metrics Part Number | Quantity |
|---|---|---|
| Waveguide Connector WR(62) to WR(42) tapered transition | 556019-172 | 1 |
| Waveguide Connector WR(62) to WR(28) tapered transition | 556026-314 | 1 |
| Attenuator jumper cable | 556023-106 | 1 |
| Alignment tool | 556005-028 | 1 |
| Alignment tool | 556005-032 | 1 |
| Alignment tool | 556005-038 | 1 |
| Spline key | 556005-011 | 1 |
| Spline key | 556005-012 | 1 |
| Spline key | 556005-013 | 1 |
| Spline key | 556005-026 | 1 |
| Hexagonal key | 556005-122 | 1 |
| Hexagonal key | 556005-123 | 1 |
| Hexagonal key | 556005-124 | 1 |
| Hexagonal key | 556005-125 | 1 |

## I-4. GENERAL DESCRIPTION

The Model SPA-10 Panoramic Spectrum Analyzer includes an i-f Indicator section (upper panel) and a Composite Tuning Head (lower panel). The Indicator which actually performs the analysis is

basically a broad-band scanning heterodyne panoramic receiver which combines high sensitivity, selectivity, and simplicity of operation. The Composite Tuning Head converts incoming signals to the acceptance slot (160 megacycles $\pm$ 40 megacycles) of the broad-band i-f Indicator. Amplitude versus frequency displays are presented on a 5-inch cathode-ray tube. The Composite Tuning Head contains a 6-band illuminated slide-rule frequency dial calibrated in megacycles. When a frequency band is selected by the operator, the local oscillator and mixer which correspond to the chosen frequency range are switched into the Tuning Head circuitry. The i-f output of the mixer is amplified and is then passed to the Indicator. Coaxial and waveguide inputs are provided on the Tuning Head front panel. External sync and marker modulation input jacks are also located on the Tuning Head front panel. The Tuning Head has variable coaxial r-f attenuation as well as a means for checking internal voltages and currents within the unit.

The Indicator CRT presents a means for observing frequency components of the input signals and for comparing their relative amplitudes. Power, linear, and logarithmic measurements can be obtained through the observance of signals on calibrated vertical scale-graduations on the CRT face. Frequency segments as narrow as 200 kilo-

cycles or as wide as 80 megacycles can be displayed along the CRT horizontal axis. A marker oscillator pip provides the means for measuring the frequency difference between points on the baseline. Marker sidebands also provide a means for determining the frequency difference between signals on the CRT. These sidebands are produced by modulating the marker with a known external frequency. The front panel of the SPA-10 contains controls for regulating the position, brightness and clarity of CRT signals. Also, sweep rate, sweep width and sweep synchronization controls are provided to enable the operator to obtain a stable, well defined signal.

## I-5. ELECTRICAL CHARACTERISTICS

Sensitivity and Dispersion Ranges:

| | |
|---|---|
| Frequency Range | 10 megacycles to 43,000 megacycles in 6 bands (selected by range switch). |
| Sweep Width (Dispersion) | 200 kilocycles to 5 megacycles for input frequencies, 10 megacycles to 100 megacycles. |
| | 200 kilocycles to 80 megacycles for input frequencies, 100 megacycles to 43 KMC. |

Table I-2 presents the capabilities of the analyzer for each frequency range.

Table I-2. Capabilities of Analyzer

| Band | Frequency Range | Tuning Head Oscillator Operation | ** Sensitivity | Input Termination (50 ohms) |
|---|---|---|---|---|
| 1 | 10-680 mc | Fundamental Triode | -95 to -105 dbm | Type N |
| 2 | 360,-2,360 mc | 3rd Harmonic Triode | -85 to - 95 dbm | Type N |
| 3 | 2,200-6,040 mc | Fundamental Klystron | -90 to -100 dbm | Type N |
| 4 | 4,640 - 12,240 mc | 2nd Harmonic Klystron | -80 to -95 dbm | Type N |
| 5 | 12,000-18,000 mc | 4th Harmonic Klystron | -70 to -85 dbm | UG-419/U |
| 5-6 | 18,000-26,500 mc | 4th & 7th Harmonic Klystron | -60 dbm nom | UG-595/U* |
| 6 | 26,500-43,000 mc | 7th Harmonic Klystron | -50 dbm nom | UG-599/U* |

*Adapters furnished

** Minimum discernible signal. Best sensitivity is obtained with narrow band scans and high selectivity ( near minimum i-f bandwidth).

RF ATTENUATORS: For bands 1 thru 4 (10 megacycles to 12.24 KMC) a 100 db adjustable range is provided. For bands 5 and 6, waveguide attenuators are available upon request.

| | |
|---|---|
| FREQUENCY ACCURACY: | Scale calibrations are accurate to ± 1 per cent or ±1 megacycle, whicever is larger. The Tuning dial has 6 scales. |
| I-F BANDWIDTH: | Adjustable from 1 kilocycle to 80 kilocycles. |
| IF ATTENUATORS: | 0-40 db in 1 db steps. 0 to 20 db smooth control; Accuracy: 0.05 db per db. |
| MAXIMUM PERMISSIBLE INPUT LEVELS: | 250 milliwatts through input attenuators. -40 dbm into direct inputs to avoid distortion due to dynamic overload. |
| DISPLAY FACILITIES: | 5 inch CRT (5ADP1) furnished, high persistence CRT available. Oscilloscope camera mounting bezel, adjustable scale illumination, and CRT scale with calibrations engraved on reverse side for minimum parrallax are provided. |
| AMPLITUDE SCALE CALIBRATIONS: | (Vertical CRT deflections): Linear, 40 db Logarithmic and Power (square law). |
| SWEEP REPETITION RATE: | Continuously variable from 1 cps to 60 cps; synchronization from line external source or free running. On calibration setting, line frequency wave appears on screen for visual sweep rate calibration and adjustment for synchronization with line frequency. |
| FREQUENCY MARKERS: | VFO for sweep width calibration has a calibrated scale of 0 to ±40 megacycles. The 0 to ±3 megacycles expanded portion of scale has scale divisions every 250 kilocycles with an incremental accuracy of ± 50 kilocycles. The ± 3 megacycles to ±40 megacycles portion of the scale has scale divisions every 2.5 megacycles with an incremental accuracy of ± 500 kilocycles.<br><br>Marker Modulation input is used with an external signal generator containing frequencies of 10 kilocycles to 10 megacycles for simultaneous sideband marker pip presentation on either side of internal marker oscillator pip. Frequency |

spacing of calibrated marker pips is determined by an external generator.

Optional:
Crystal controlled frequency markers (0.01 per cent accuracy) every 1, 10, and 100 megacycles for checking entire r-f tuning dial range.

I-6. PHYSICAL CHARACTERISTICS

CABINET DIMENSIONS: 19-7/16 inch high; 17-9/16 inch wide; 19-1/8 inch deep.

RACK MOUNT VERSION RM-1/10: 19 inches wide; includes 3-1/2 inch high sliding tray and Dress Strips.

POWER REQUIREMENTS: 115/230 volts nominal, 50-60 cps. 400 watts (approximately). Equipment normally wired for 115 volts.

WEIGHT: 110 lbs. (approximately)

I-7. TUBE COMPLEMENT

a. COMPOSITE TUNING HEAD.

| Circuit Ref. Symbol | Type | Function |
|---|---|---|
| CR201 | IN1089 | Power Supply Rectifier |
| CR203 | IN1089 | Power Supply Rectifier |
| CR205 | IN1089 | Power Supply Rectifier |
| CR207 | IN1089 | Power Supply Rectifier |
| CR209 | IN1089 | Power Supply Rectifier |
| CR211 | IN1089 | Power Supply Rectifier |
| CR213 | IN1089 | Power Supply Rectifier |
| CR215 | IN1089 | Power Supply Rectifier |

| Circuit Ref. Symbol | Type | Function |
|---|---|---|
| CR217 | CEC4050 | Power Supply Rectifier |
| CR219 | CEC4050 | Power Supply Rectifier |
| CR221 | 6313 Pacific Semiconductor | Zener Diode |
| K201 | FXR317-010242-3 | Control Relay |
| K202 | FXR317-010242-3 | Control Relay |
| K203 | FXR317-010242-3 | Control Relay |
| K204 | FXR317-010242-3 | Control Relay |
| K205 | FXR317-010242-3 | Control Relay |
| V201 | 6AF4A | Local Oscillator 170-840 Megacycles |
| V207 | 6BL6 | Local Oscillator 2400-6000 Megacycles |
| V203 | 5842 | Preamplifier-First Stage |
| V205 | 5842 | Preamplifier - Second Stage |

b. INDICATOR UNIT.

| Circuit Ref. Symbol | Type | Function |
|---|---|---|
| Power Supply | | |
| CR101 | 10AG8 Electronic Devices | 375 Volt Power Rectifier |
| CR103 | 10AG8 Electronic Devices | 375 Volt Power Rectifier |
| CR105 | 10AG8 Electronic Devices | 375 Volt Power Rectifier |
| CR107 | 10AG8 Electronic Devices | 375 Volt Power Rectifier |

| Circuit Ref. Symbol | Type | Function |
|---|---|---|
| CR109 | 10AG4 Electronic Devices | 225 Volt Power Rectifier |
| CR111 | 10AG4 Electronic Devices | 225 Volt Power Rectifier |
| CR113 | 10AG4 Electronic Devices | 225 Volt Power Rectifier |
| CR115 | 10AG4 Electronic Devices | 225 Volt Power Rectifier |
| CR117 | TDO2 Electronic Devices | 950 Volt Power Rectifier |
| CR119 | TDO2 Electronic Devices | 950 Volt Power Rectifier |
| CR121 | TDO2 Electronic Devices | 950 Volt Power Rectifier |
| CR123 | TDO2 Electronic Devices | 950 Volt Power Rectifier |
| CR125 | 10AT1 Electronic Devices | 28 Volt Rectifier |
| CR127 | 10AT1 Electronic Devices | 28 Volt Rectifier |
| CR129 | 10AT1 Electronic Devices | 28 Volt Rectifier |
| CR131 | 10AT1 Electronic Devices | 28 Volt Rectifier |
| CR133 | SQ13HP Electronic Devices | CRT High Voltage Diodes |
| CR135 | SQ13HP Electronic Devices | CRT High Voltage Diodes |
| V101 | 6650 | Regulator |
| V102 | 6650 | Regulator |
| V103 | 6650 | Regulator |
| V104 | 12AX7 | DC Amplifier |
| V105 | 0G3 | Reference Tube |
| V106 | 12AX7 | DC Amplifier |
| V107 | 0A2 | Voltage Regulator |

| Circuit Ref. Symbol | Type | Function |
|---|---|---|
| V108 | 6550 | Series Regulator |
| V109 | 6AH6 | DC Amplifier |
| V110 | OD3 | Voltage Regulator |
| V111 | OD3 | Voltage Regulator |
| V112 | OD3 | Voltage Regulator |
| V113 | OD3 | Voltage Regulator |
| **CRT Power Supply** | | |
| CR1 | 10AT1 Electronic Devices | High Voltage Rectifier |
| CR2 | SQ130HP - Electronic Devices | High Voltage Rectifier |
| V114 | 6BQ5 | 100KC Oscillator |
| Wide Band Circuit | | |
| V301 | 5842 | Amplifier |
| V302 | 5842 | Amplifier |
| V303 | 6AF4A | Mixer |
| V304 | 12AX7 | AGC Amplifier |
| V305 | 6AQ5A | AGC Amplifier |
| V306 | 6AW5A | Sawtooth Driver |
| V307 | 6AF4A | Swept Oscillator |
| Marker Circuit | | |
| CR401 | IN34A | Balanced Mixer Diode |
| CR403 | IN34A | Balanced Mixer Diode |
| CR405 | IN34A | Balanced Mixer Diode |

| Circuit Ref. Symbol | Type | Function |
|---|---|---|
| CR407 | IN34A | Balanced Mixer Diode |
| V401 | 6AF4A | Marker Oscillator |
| Video IF Schematic | | |
| V601 | 6688 | Amplifier |
| V602 | 6688 | Amplifier |
| V603 | 6J6 | Mixer |
| V604 | 6AB4 | Cathode Follower |
| V605 | 6CB6 | 6.5 Megacycle Amplifier |
| V606 | 6AB4 | Cathode Follower |
| V607 | 6CB6 | Amplifier |
| V608 | 6AH6 | Amplifier |
| V609 | 6AL5 | Detector |
| V610 | 7699 | Vertical Amplifier |
| V611 | 12AU7 | Intensifier |
| V612 | 6CB6 | Blanker |
| Horizontal Generator | | |
| V801 | 12AT7 | Sync Amplifier |
| V802 | 6CB6A | Sawtooth Generator |
| V803 | 6AB4 | Cathode Follower |
| V804 | 12AU7A | Horizontal Amplifier |

## I-8. FRONT PANEL CONTROLS

(See Figure I-1)

The controls, indicators and jacks mounted on the front panels of the Indicator and the Tuning Head are presented in table I-3.

Table I-3. Controls, Indicators and Jacks for Model SPA-10

| Index No. | Item | Item Function |
|---|---|---|
| 1 | BRILLIANCE control | Increases the intensity of the CRT display. |
| 2 | CALibration SYNChronization SELector | In CAL position - Injects 60 cps on the baseline for calibration of sweep rate. In LINE position- Controls horizontal sweep rate through internal sync (power line frequency). In EXT position - Permits horizontal sweep synchronization with suitable signal connected to EXT SYNC connector on Tuning Head front panel. |
| 3 | SYNC AMPLitude | Adjusts amplitude of sweep rate synchronizing signal. |
| 4 | Cathode-ray tube indicator face | Displays line spectrum of marker and inputs on calibrated graticule. See index number 28 for explanation of graticule markings. |
| 5 | POWER/SCALE ILLUMInation control | When turned clockwise from a fully counterclockwise position, this control applies ac power to the unit. Further clockwise rotation of the control causes brightening of edge lighting indicators for the CRT screen. |
| 6 | SWEEP RATE control | Varies CRT sweep rate between 1 cps and 60 cps |
| 7 | Marker MEGACYCLES dial | When marker pip is moved from one point to another using the MARKER-FREQUENCY control, the marker dial reads the difference between |

| | | |
|---|---|---|
| | | these two points in megacycles. |
| 8 | MARKER-FREQUENCY control | Varies marker frequency from +40 to - 40 megacycles. |
| 9 | MARKER-LEVEL control | Varies amplitude of marker pip on CRT screen. |
| 10 | Variable IF ATTENuator 20 DB control | Provides vernier attenuator action up to 20 db. The total attenuation obtained with this control is additive to the db attenuation of the IF ATTEN toggle switches. Maximum combined IF attenuation obtainable from the toggle switches and the IF ATTEN 20 DB control is 60 db. |
| 11 | SWEEP WIDTH (Dispersion) control | Varies sweep width from 200 kilocycles to 80 megacycles except as indicated in the following note. |

NOTE

When the Range selector switch is in the 10 MC - 3 KMC position and when the Tuning Head frequency indicator reads between 10 and 100 megacycles, the sweep width can be varied only from 200 kilocycles to 5 megacycles.

| | | |
|---|---|---|
| 12 | IF ATTENUATOR toggle switches | Insert i-f attenuation in steps with maximum attenuation equaling 40 db. |
| 13 | Frequency dial | Indicates, by means of a pointer on an illuminated scale, the frequency that the unit is capable of accepting and presenting on the face of the CRT. |

| | | |
|---|---|---|
| 14 | Internal check meter | Operates in conjunction with INTERNAL CHECK selector switch for monitoring system currents and voltages. The required internal check meter readings to be obtained for normal operation are presented in table 1-4. |
| 15 | INTERNAL CHECK selector switch | Used in conjunction with the internal check meter to check klystron voltage and current, B+, line voltage, and crystal signal and bias. |
| 16 | DIRECT INPUT 12-43 KMC waveguide connector | Used for receiving input signals within the 12 to 43 KMC range. |
| 17 | Frequency TUNING control | Positions the dial pointer at the signal frequency to be viewed on the CRT. |
| 18 | RANGE selector switch | Selects the operating range of Tuning Head. |
| 19 | MARKER MODulation input jack | Accepts external oscillator input whose frequency modulates the marker. The sideband pips produced by the marker modulation permit small sweep width measurements. |
| 20 | EXT SYNChronization input jack | Accepts external sync (signals) which synchronize the horizontal sweep on the CRT. Used when the CAL-LINE-EXT selector switch is in the EXT position. |
| 21 | ATTENuator INPUT jack (1-12 KMC) | Accepts and attenuates signals between 1 KMC and 12 KMC. |
| 22 | ATTENuator OUTPUT 1-12 KMC jack | When input signals are supplied to the ATTEN INPUT jack, the ATTEN OUTPUT jack supplies attenuated output signals between 1 KMC and 12 KMC (jumped cable is supplied for connection to 1-12 |

| | | |
|---|---|---|
| | | KMC input). |
| 23 | ATTENuator INPUT jack (10 MC - 1 KMC) | Accepts and attenuates signals between 10 megacycles and 1 KMC. |
| 24 | ATTENuator OUTPUT 10 MC - 1 KMC jack | When input signals are supplied to the ATTEN INPUT jack, the ATTEN OUTPUT jack supplies attenuated output signals between 10 megacycles and 1 KMC (Jumper cable is supplied for connection to 10 MC - 1 KMC INPUT JACK). |
| 25 | INPUT 10MC-12KMC jack | Used for accepting signals below -40 dbm in the 10 megacycle to 12 KMC range. |
| 26 | RF ATTENUATOR control | Provides 100 db of attenuation (above initial insertion loss of approximately 10 to 30 db) in addition to the attenuation made available through the use of the IF ATTENUATOR toggle switches. Calibration markings on dial should be used only as arbitrary reference points. (Used in 10 MC - 1 KMC and 1 - 12 KMC ranges). |
| 27 | IF BANDWIDTH control | Varies the bandwidth of the third (6.5 megacycle)i-f amplifier, |

NOTE

The IF BANDWIDTH control is used to resolve closely spaced signals, to improve the signal to noise ratio of low level signals, or to improve the definition and brightness of pulse displays. As the IF BANDWIDTH control is adjusted to obtain these conditions, the amplitude of the CRT presentation may vary.

| | | |
|---|---|---|
| 28 | AMPLITUDE SCALE selector switch | Selects linear, logarithmic or power (square law) amplitude presentations. When the AMPLITUDE SCALE selector switch is in LOG position, signals having a 40 db (100:1) voltage ratio can be viewed on the screen. In this switch position, the calibration dots on the left side of the screen are used. The calibration range is from 0 db to -40 db. In the LIN position, signals having a 20 db (10:1) amplitude ratio can be viewed on the screen.Half scale is 6 db down. In this switch position, the horizontal calibration lines and numbers on the right hand side of the screen are used. The linear scale is calibrated in ten divisions. When the AMPLITUDE SCALE selector switch is in the PWR (power) position, the pip height varies as the square of the signal voltage for an approximate range of 3:1 (10 db). Half scale is 3 db down. This switch position is used primarily to measure or observe small differences between the level of signal peaks. For example - to measure the difference in level between two peaks, adjust the higher peak to full scale deflection; should the lower peak then measure 1/4 scale, the input voltage ratio of the peaks would be 1:2, since the square root of power ratio equals voltage ratio. |
| 29 | ASTIGmatism screwdriver adjustment | Adjusts for uniform focus on face of CRT. |

| | | |
|---|---|---|
| 30 | VIDEO FILTER control | Supresses unwanted effects in video such as noise and spurious beating between adjacent signals. |
| 31 | INTENSIFIER control | Causes signals with a fast "rise time" to increase in brightness in respect to the CRT base line. When using this control, turn the BRILLIANCE control to a point where the CRT baseline almost disappears. |
| 32 | Vertical POSition screwdriver adjustment | Shifts the CRT baseline in a VERTICAL direction. |
| 33 | Horizontal POSition screwdriver adjustment | Shifts the CRT base line in a horizontal direction. |
| 34 | FOCUS control | Adjusts the sharpness of the CRT display. |
| 35 | LINE SIZE screwdriver adjustment | Adjusts the size of the horizontal base line. |
| 36 | SPECTRUM CENTERING control | Operates as a "fine" adjustment in conjunction with TUNING conrol to center spectrum on face of CRT. |

NOTE

The H POS control and the LINE SIZE control should be left at original factory settings unless vertical positioning or line size adjustments are found to be necessary during alignment procedures. Adjustment of these controls by operating personnel may result in displacement of the display with respect to CRT screen calibrations.

## I-9. CHECK METER

The positions of the INTERNAL CHECK selector switch and required indications on the check meter are shown in table 1-4.

Table I-4. INTERNAL CHECK Meter Indications

| INTERNAL CHECK Switch Position | Measures | Required check Meter Indication |
|---|---|---|
| ANODE V | Anode to cathode voltage of klystron | Mid scale (Green N) (reads only in the 3-12 KMC and 12-43 KMC ranges) |
| +250 | System 250 volt B+ supply | Mid-scale (Green N) |
| Line V | Input line voltage to SPA-10 | Any scale reading (105 to 125 volts) |
| KLYSTRON CURrent | Cathode current of klystron | .4 to .8 (in green KLYSTRON AREA) (reads only in 3-12 KMC and 12-43 KMC ranges) |
| XTAL BIAS | DC crystal bias current at operating mixer in Tuning Head | Any reading other than zero |
| XTAL CURrent | Rectifier signal current at crystal of operating mixer in Tuning Head | Any reading other than zero |

NOTE

The INTERNAL CHECK selector switch does not remain in the XTAL CUR position

during unit operation. The switch is spring loaded and, upon release, returns to the XTAL BIAS position.

I-10. TERMS AND DEFINITIONS

a. PANORAMIC RECEPTION.

Panoramic reception permits continuous visual observation on a CRT of the presence and relative strength of all signals within a wide frequency range above and below the frequency to which the analyzer may be tuned. When used in communications, it permits the monitoring of a wide frequency band, and quickly indicates the location of any type of signal and permits the interpretation of its characteristics. It also indicates the presence of open channels to allow for a quick selection of transmitting frequencies. When used in laboratory work it facilitates the diagnosis of any waveform and speeds up verification of laboratory problems.

b. SWEEP WIDTH.

Sweep width is the band, measured in cycles, kilocycles or megacycles, which can be observed by panoramic reception and which corresponds to the range of oscillator sweep in the Singer Metrics equipment. (A synonym for "dispersion")

c. BANDWIDTH.

Bandwidth is the frequency difference between two 3 db points on a signal pip provided that the sweep width is slow enough so as not

to cause pulse stretching of the signal pip. See figure I-II.

d. BASELINE.

Baseline is the horizontal line swept across the cathode-ray tube by the electron beam whose motion is controlled by the sawtooth generator and its associated amplifiers.

e. FREQUENCY SWEEP AXIS.

Frequency sweep axis is the line along which the signal deflections are produced and which can be calibrated in frequency according to a given frequency scale (a synonym for "baseline").

f. CENTER FREQUENCY.

Center frequency is the frequency of the signal received on that part of the frequency sweep axis corresponding to zero sweep voltage applied to the reactance modulator.

g. RESOLUTION.

Resolution is the frequency separation between the peaks of two signal pips when the signal pip 3 db points merge. This characteristic corresponds to "selectivity" in ordinary receivers. The smaller the frequency difference, the better the resolution.

h. SWEEP RATE.

Sweep rate is the number of times per second the electron beam sweeps across the cathode-ray tube (sometimes called "sweep frequency").

i. DEFLECTION AMPLITUDE.

Deflection amplitude is the visual equivalent of signal input voltage. It is the height of a given signal deflection measured from the baseline to the top of the deflection.

j. SWEEPER.

Sweeper is the reactance modulated oscillator whose output is used to heterodyne with the input signal in the mixer circuit to obtain the panoramic reception described above.

k. MARKERS.

Markers are the calibrated beat oscillations injected into the first i-f amplifier used to measure the frequency difference between any signals which appear simultaneously on the CRT screen.

l. LINE SIZE.

Line size denotes the horizontal distance covered by the baseline

m. CRYSTAL BIAS.

Crystal bias is the current applied at the crystal mixers to cause the mixer to operate on the linear portion of its characteristic curve. This linear operation provides greater sensitivity and distortion free operation.

# CHAPTER II - INSTALLATION

## II-1. INITIAL INSPECTION

This instrument has been tested and calibrated before shipment. Only minor preparations are required to put the instrument in operation.

If damage to the case is evident when delivery is made, have the person making the delivery describe the damage and record the description of the damaged case on all copies of the delivery receipt. Most public carriers do not recognize claims for concealed damage if such damage is not reported within 15 days after delivery. All shipping containers should be opened and the equipment should be inspected before 15 days elapse. If damage is discovered, whether concealed or obvious when delivered, call or write the carrier and ask that an inspection be made by their agent.

Although the carrier is liable for any damage incurred through shipment, Singer Metrics Division, The Singer Manufacturing Company, will assist in describing and providing for repair or replacement of damaged items.

The equipment is shipped with all tubes and crystals installed.

Figures II-1, II-2 and II-3 present dimensional drawings to be used as a guide when selecting an installation area for the SPA-10.

## II-2. INTERCONNECTING PROCEDURE

### a. POWER SUPPLY

The power supply of the SPA-10 Spectrum Analyzer is normally factory wired for 115-volt, 50-60 cycle operation.

### b. CABLES

The equipment is supplied with an integral power line cord which should be connected to a suitable source of AC power. When the equipment is not in use, the line cord should be stored in the recessed compartment located at the rear of the equipment. An attenuator jumper cable is also included as an accessory item. All other cables necessary for the operation of the equipment are located inside the cabinet and are connected at the factory before shipment.

### c. VENTILATION

For adequate cooling, a 7-inch clearance must be allowed behind the unit, otherwise, restricted air flow may cause overheating.

## II-3. INSTALLATION ADJUSTMENTS AND CHECKS FOR INDICATOR UNIT

### a. POWER SCALE ILLUM.

Turn the POWER SCALE ILLUM control clockwise. One of the slide rule scales on the frequency-indicator should light. Clockwise rotation of the POWER SCALE ILLUM control should increase the illumination of the CRT screen edge-lighting. Turn the IF ATTEN 20 DB control fully clockwise. Turn the BRILLIANCE control two-thirds maximum clockwise. The base line trace should appear on

the CRT within 30 seconds.

b. FOCUS.

Turn this control from a counterclockwise position to a fully clockwise position. The CRT sweep trace should change from blurred to sharp to blurred. Return the control to the position which gives the sharpest trace.

c. BRILLIANCE.

Turn this control from a counterclockwise position to a fully clockwise position. The intensity should vary from low to high. When the control is fully counterclockwise, the CRT baseline will not be visible. When the control if fully clockwise, the CRT baseline should be at its brightest. The focus of the baseline may vary when the BRILLIANCE control is fully clockwise but this is a normal indication. Return the BRILLIANCE control to the position which causes a sharp, bright sweep-trace to appear on the CRT.

d. SWEEP RATE AND SYNC AMPL.

Set the CAL-SYNC SEL switch to the CAL position. Turn the SYNC AMPL control fully counterclockwise and turn the SWEEP RATE control from its maximum clockwise position in a counterclockwise direction until a single sine wave appears on the CRT screen. The presentation should be almost stationary, with a slight drift to the left. Slowly turn the SYNC AMPL control clockwise until the CRT presentation becomes steady. Further rotation of the SYNC AMPL control will tend

to shorten the length of the baseline trace. The best setting of the SYNC AMPL control is that which combines a minimum sync amplitude setting with a stationary CRT display. The one cycle presentation indicates a 60 cps sweep rate. Adjust the SWEEP RATE control in conjunction with the SYNC AMPL control to obtain CRT sweep presentations of 30 cps (2 cycle presentation), 20 cps (3 cycle presentation) and 15 cps (4 cycle presentation). Figure II-4 is a typical CRT screen presentation showing 2 cycles of line frequency which indicates a 30 cps sweep rate (25 cps for a 50 cps power line frequency).

The sweep rate at any position is equal to 60 cps divided by the number of cycles visible. At low sweep rates it is easier to measure the time per sweep with a stop watch rather than to count cycles. A one second sweep CRT presentation should be reached just before the SWEEP RATE control reaches its counterclockwise position.

e. CONTROL SETTINGS.

For the following checks, set the front panel controls to the starting positions listed below:

| Control | Setting |
|---|---|
| SWEEP WIDTH | Fully clockwise |
| IF BANDWIDTH | Fully clockwise |
| BRILLIANCE | Desired trace brightness |

| Control | Setting |
|---|---|
| INTENSIFIER | Fully counterclockwise |
| FOCUS | Sharp trace |
| SPECTRUM CENTERING | Center |
| AMPLITUDE SCALE | LINear |
| IF ATTENUATOR toggle switches | Down position (no attenuation) |
| IF ATTENuator 20DB (variable) | Fully counterclockwise |
| CALibration SYNChronization SELector | LINE |
| SWEEP RATE | 60 cps |
| SYNC AMPLitude | To lock sweep |
| VIDEO FILTER | Fully counterclockwise |
| MARKER FREQUENCY control | 0 |
| MARKER LEVEL | OFF |
| RANGE | 10 MC - 3 KMC |
| INTERNAL CHECK selector switch | XTAL BIAS |
| TUNING | 700 on bottom tuning scale |
| RF ATTENUATOR | 100 |

f. IF ATTEN 20 DB.

1. Counterclockwise rotation of the control increases the gain of the i-f amplifiers in the equipment. To check the operation of the IF ATTEN 20 DB control, turn the control slowly from a clockwise to a counterclockwise position. The noise

display on the CRT should increase from 0 to from 1/8 to 1/2 of full scale deflection.

2. It is recommended that for normal operation, the IF ATTEN 20 DB control be adjusted to a position that causes 1/16 to 1/8 inch of noise on the CRT when the other controls are set as in paragraph II-3e.

g. MARKERS, SWEEP WIDTH and SPECTRUM CENTERING.

NOTE

Be sure that the equipment has had a five minute warm-up period (minimum) before the following procedures are attempted.

1. Turn the IF ATTEN 20 DB control to a position which causes 1/8 inch of noise deflection on the CRT.

2. Turn the MARKER LEVEL control in a clockwise direction until a full scale marker pip appears on the CRT.

3. Vary the MARKER-FREQUENCY control between -40 and +40 megacycles. The marker pip should travel across the CRT screen from the -0.5 vertical mark (± 1/2 screen division) to the +0.5 vertical mark (± 1/2 screen division).

4. Turn the MARKER-FREQUENCY control to the zero position. The marker pip should coincide with the -0+ center CRT screen calibration (± 1/4 screen division).

5. With the MARKER-FREQUENCY control set at the zero position, turn the SWEEP WIDTH control fully counterclockwise (minimum sweep width) and keep the marker pip centered by adjusting

the SPECTRUM CENTERING control. The counterclockwise setting of the SWEEP WIDTH control should cause the marker pip to appear as an expanded pip display. (See figure II-5.)

6. Return the SWEEP WIDTH control to a fully clockwise position.

h. IF BANDWIDTH.

With the marker pip centered, adjust the MARKER-LEVEL control for full scale marker pip deflection. Adjust the SWEEP WIDTH control so that the pip width at 1/2 scale is approximately 4 screen divisions. Slowly turn the IF BANDWIDTH control in a counterclockwise direction. The pip width should decrease. At this time, a change in pip height may occur. Rotation through the full range of the IF BANDWIDTH control will result in a major change in pip height. It will also be noticed that small convolutions or "ringing" will appear on the trailing edge (left side) of the pip. Optimum resolution occurs when the first convolution beyond the apex of the pip dips into the baseline. (See figure II-6). Return IF BANDWIDTH and SWEEP WIDTH controls to a fully clockwise position.

i. AMPLITUDE SCALE.

1. Set the front panel controls as follows:

| Control | Setting |
|---|---|
| SWEEP WIDTH | Approximately 1/4 clockwise |
| IF BANDWIDTH | Fully clockwise |

| Control | Setting |
|---|---|
| BRILLIANCE | Desired trace brightness |
| INTENSIFIER | Fully counterclockwise |
| FOCUS | Sharp trace |
| SPECTRUM CENTERING | Center |
| AMPLITUDE SCALE | LINear |
| IF ATTENUATOR toggle switches | Down position (no attenuation) |
| IF ATTENuator 20DB (variable) | 1/8 inch noise on CRT |
| CALibration-SYNChronization SELector | LINE |
| SWEEP RATE | 60 cps |
| SYNChronization AMPLitude | To lock sweep |
| VIDEO FILTER | Fully counterclockwise |
| MARKER-FREQUENCY control | 0 |
| MARKER LEVEL | OFF |
| RANGE | 10 MC - 3 KMC |
| INTERNAL CHECK selector switch | XTAL BIAS |
| TUNING | 680 on bottom tuning scale |
| RF ATTENUATOR | 100 |

2. Connect a signal generator 160 megacycle signal to the 10 MC - 12 KMC input connector. Adjust the level of the generator for a 1000 microvolt output. Adjust the IF ATTEN to obtain a full scale pip presentation on the CRT. Turn the signal generator

until the input signal appears at the left side of the baseline. The measurements taken in the following steps should fall within ±5 per cent (± 1/2 division).

3. Reduce the generator output in 100 microvolt steps. Each change in input level as read on the signal generator should result in a pip height on the CRT which corresponds to the appropriate VOLTAGE (LIN) screen calibration on the right hand edge of the screen (0.9 for 900 microvolt input, 0.8 for 800 microvolt input). (See figure III-1 for proper method of observing CRT screen.)

4. Set the AMPLITUDE SCALE switch to the LOG position. Adjust the generator for an output of -20 dbm. Adjust the IF ATTEN 20 DB control to obtain a full scale pip. Reduce the generator output to -60 dbm. The pip height should decrease to the -20 DB screen calibration (midscale). Reduce the generator output to -80 dbm. The pip height should decrease to the -40 DB screen calibration (next to the bottom line).

5. Set the AMPLITUDE SCALE selector switch to the LIN position. Adjust the generator for an output of -60 dbm. Adjust the IF ATTEN 20 DB control to obtain a full scale pip. Set the six IF ATTENUATOR toggle switches (1 DB, 2 DB, 2 DB, 5 DB, 10 DB, 20 DB) to the ON position (UP). The pip should disappear. Increase the generator output to -40 dbm. The pip should return to full scale amplitude ±2 divisions.

6. Set the AMPLITUDE SCALE selector switch to the PWR position. Adjust the generator for 1000 microvolt output. Adjust the IF ATTEN 20 DB control to obtain a full scale pip. Reduce the generator output to 700 microvolts. The pip height should drop down to approximately midscale.

j. VIDEO FILTER .

1. Set the front panel controls to the positions listed in paragraph II-3i.

2. Adjust the MARKER LEVEL control for a half scale pip presentation on the CRT.

3. Slowly turn the VIDEO-FILTER control in a clockwise direction. The noise on the CRT should become filtered (should disappear) and the marker pip should integrate and shift slightly. A greater filtering effect should be noted as the VIDEO FILTER control is turned in a more clockwise direction. Return the VIDEO FILTER control to the counterclockwise position. In normal operation, the selected position of the VIDEO FILTER control should be that position which gives the clearest CRT presentation with a minimum loss of signal amplitude. It should be noted that sweep rate will have effect on the clarity of the CRT presentation; the slower the sweep rate, the better the presentation. Faster sweep rates will degrade the presentation beyond use.

k. SWEEP RATE AND SYNC AMP.

1. Set the CAL-SYNC SEL switch to the CAL position. Turn the SYNC AMP control fully counterclockwise and turn the SWEEP RATE control fully clockwise. As the SWEEP RATE control is slowly turned in a counterclockwise direction, one cycle of line frequency should appear. If the CRT presentation jitters, slowly turn the SYNC AMP control clockwise until the presentation becomes steady. If the line frequency is 60 cps, the one cycle presentation indicates a 60 cps sweep.

2. Perform the preceeding procedure with separate positions of the SWEEP RATE control to obtain indications of a 30 cps sweep (2 cycle presentation), a 20 cps sweep (3 cycle presentation), and a 15 cps sweep (4 cycle presentation). The sweep rate at any position is equal to 60 cps divided by the number of cycles visible. At low sweep rates, it is easier to time the number of sweeps per second with a stop watch rather than count cycles. A 1-second CRT sweep rate should be visible when the SWEEP RATE control is fully counterclockwise.

l. INTENSIFIER

1. Set the front panel controls to the positions listed in paragraph II-3i.

2. Turn the SWEEP WIDTH control fully clockwise.

3. Adjust the MARKER FREQUENCY control for a full scale pip on the CRT.

4. Turn the BRILLIANCE control counterclockwise until the baseline just disappears.

5. Turn the INTENSIFIER control clockwise until the marker pip appears. The marker pip shoud be easily discernable although the baseline may not be visible. Note that this check should not be performed where the ambient light is too bright or where direct light is allowed to fall on the CRT screen.

m. FRONT PANEL SCREW-DRIVER ADJUST CONTROLS.

The following screw-driver adjust controls are not used during the course of normal operation. They may, however, require occasional adjustment to set up proper CRT presentation.

1. ASTIGmatism. As brightness of the trace is varied, it may become difficult to focus the trace throughout its length. The ASTIGmatism control should be adjusted to provide best over-all focus of the CRT presentation.

2. Horizontal POSition.

NOTE

This control should be left at the original factory setting unless horizontal positioning adjustments are found to be necessary during alignment procedures. Adjustment of the H POS control by operating personnel may result in displacement of the display with respect to screen calibrations.

The baseline may be moved horizontally be means of the control makred H POS. Signals which are depicted as pips on the baseling will move with the baseline and, therefore, their relative positions to each other in the spectrum will not change. It is possible to move the baseline horizontally for a distance of approximately 2 scale divisions in either direction.

3. Vertical POSition.

NOTE

This control should be left at the original factory setting unless vertical positioning adjustments are found to be necessary during alignment procedures. Adjustment of the V POS control by operating personnel may result in displacement of the display with respect to screen calibrations.

The baseline may be moved vertically by means of the control marked V POS. The relative heights of the signals depicted on the baseline will not change as the baseline is raised or lowered. It is possible to move the baseline up or down approximately 1-1/2 inches.

4. LINE SIZE. The horizontal length of the trace is adjusted with the LINE SIZE control. If the trace is excessively long, resolution will be adversely affected; if the trace is too short, the scanning width will be reduced. Factory adjustment of this

control normally provides a baseline which extends approximately 1/4 inch beyond the frequency scale extremities.

II-4. INSTALLATION ADJUSTMENTS AND CHECKS FOR TUNING HEAD

The adjustments and checks presented in this section should be performed only after the installation adjustments and checks for the Indicator have been completed and the Indicator has been found to be operating correctly.

a. TUNING.

Turn the TUNING control through its complete range. The tuning scale megacycles pointer should travel from slightly beyond one end of the scale to slightly beyond the other end. The TUNING control should operate smoothly throughout its rotational range.

b. RF ATTENUATOR.

Turn the RF ATTENUATOR control through its complete range. This control should vary from 0 (maximum attenuation) and turn slightly past 100 at the opposite end.

c. RANGE CONTROL AND INTERNAL CHECK CONTROL.

Turn the POWER SCALE ILLUM control clockwise to a position where screen intensity is as desired. The INTERNAL CHECK selector switch should be set to its 5 switch positions for each position of the RANGE selector switch, while the internal check meter is observed. The XTAL BIAS, XTAL CUR, +250, and LINE V readings on the internal check meter should remain the same for each position of the RANGE selector switch. The KLYSTRON CUR and ANODE V positions of the INTERNAL CHECK selector switch should only register on the internal

check meter when the RANGE selector switch is in the 3-12 KMC and 12-43 KMC positions. See table II-1 for the required internal check meter readings for each position of the INTERNAL CHECK selector switch.

Table II-1. Internal Check Meter Indications

| INTERNAL CHECK Switch Position | Measures | Required Check Meter Indication |
|---|---|---|
| ANODE Voltage | Voltage of klystron | Reads only in the 3-12 KMC and 12-43 KMC ranges |
| +250 | System 250 volt B+ supply | Mid-Scale (Green N) |
| Line Voltage | Input line voltage to SPA-10 | Any scale reading (105 to 125 volts). |
| KLYSTRON CURrent | Cathode current of Klystron | .4 to .7 (in green KLYSTRON AREA) reads only in 3-12 KMC and 12-43 KMC ranges. |
| XTAL BIAS | DC crystal bias current at operating mixer | Any on-scale reading |
| XTAL CURrent | Rectified signal current at crystal | Any on-scale reading |

NOTE

The INTERNAL CHECK selector switch does not remain in XTAL CUR position during unit operation. The switch is spring loaded and, upon release, returns to the XTAL BIAS position.

d. 10 MC - 12 KMC INPUT AND 12-43 KMC DIRECT INPUT CHECK.

1. Set the front panel controls as follows:

(a) Turn the SPECTRUM CENTERING control to mid-position.

(b) Set the CAL SYNC SEL switch to the LINE position.

(c) Adjust the SWEEP RATE control for a 60 cycle sweep rate.

(d) Adjust the CAL SYNC SEL switch, SYNC AMPL control and SWEEP RATE control for a 60 cycle synchronized sweep.

(e) Adjust the BRILLIANCE, FOCUS, and POWER SCALE ILLUM controls as desired.

(f) Turn the VIDEO FILTER control fully counterclockwise.

(g) Turn the INTENSIFIER control fully counterclockwise.

(h) Set the AMPLITUDE SCALE switch to the LIN position.

(i) Set the IF ATTENUATOR toggle switches to the down position.

(j) Turn the SWEEP WIDTH control to a fully clockwise position.

(k) Adjust the IF ATTEN 20 DB control for 1/8 inch of noise on the CRT screen.

(l) Adjust the MARKER FREQUENCY control to zero.

(m) Adjust the MARKER LEVEL control for marker height 1/4 of the CRT screen.

2. The following method should be used to check the frequency, accuracy and the sensitivity of the Tuning Head.

(a) Insert the output of a signal generator, calibrated at -40 dbm, into either the 10 MC - 12 KMC jack or the DIRECT INPUT 12-43 KMC input jack.

(b) Set the RANGE selector switch to the position which corresponds to the frequency of the input jack being used. Adjust the frequency TUNING control until the Tuning Head frequency dial reads the same frequency as the calibrated signal generator input, The signal generator input pip should now appear on the CRT screen.

(c) Increase or decrease the attenuation of the signal generator to obtain a 1/2 scale signal pip on the CRT screen.

NOTE

If more than one pip appears, determine which pip represents the true signal using the method presented in paragraph III-2.

(d) Adjust the TUNING control until the Tuning Head marker pip coincides with the signal generator input pip on the face of the CRT.

(e) The frequency on the Tuning Head dial should now be identical to the frequency of the signal generator (within the combined maximum tolerances of both equipments). This check should be made for both direct input jacks.

e. MAXIMUM SENSITIVITY MEASUREMENT.

The purpose of this check is to determine the sensitivity of the

receiver (signal to noise ratio measured in dbm) with minimum sweep width and maximum resolution obtainable.

1. The front panel control settings for this check are listed as follows:

| Control | Setting |
|---|---|
| SWEEP RATE | 30 cps synchronized |
| VIDEO FILTER | Counterclockwise |
| AMPLITUDE SCALE | LINear |
| SWEEP WIDTH | Half range |
| IF BANDWIDTH | Fully clockwise |
| IF ATTENUATOR 20 DB (variable) | For 1/2 scale CRT deflection |
| MARKER | Fully counterclockwise |
| RANGE | 12-43 KMC |
| TUNING control | Turn until frequency dial indicator reads frequency to be viewed. |

2. Using a calibrated signal generator, connect the desired CW test signal to the 12-43 KMC DIRECT INPUT connector. Center the input frequency on the face of the CRT with the SPECTRUM CENTERING control. (see figure II-7a).

3. Slowly turn the SWEEP WIDTH control counterclockwise while continually optimizing resolution with the IF BANDWIDTH control. Continue to turn the IF BANDWIDTH control counterclockwise until the point just before "FM breakup" occurs on the CRT (See figure II-7b).

4. Increase the gain of the signal, if required, to keep the signal approximately half scale, by turning the IF ATTEN 20 DB control in a counterclockwise direction. Keep the signal horizontally

centered with the SPECTRUM CENTERING control (See figure II-7c).

5. Turn the IF ATTEN 20 DB control to obtain one vertical division of noise or, to a maximum setting if one division of noise cannot be obtained. Using the signal generator output attenuator, reduce the pip amplitude to a point where the CRT noise plus the input signal equal twice the height of the original CRT noise level. (See figure II-7d for signal + noise = twice noise).

NOTE

Observe that the criterion used in determining maximum sensitivity is the signal to noise ratio. The total amount of noise present on the screen is irrelevant as long as a 2 to 1 ratio or better, can be maintained.

6. Read the analyzer sensitivity reading on the signal generator. Maximum and minimum sensitivity ratings for all bands can be found in table 1-2.

## CHAPTER III - OPERATION

### III-1. GENERAL OPERATION FOR SPECTRUM ANALYZER, MODEL SPA-10

a. GENERAL.

The Panoramic Spectrum Analyzer Model SPA-10 is a narrow-band superheterodyne receiver-indicator which is divided physically into two major components; the Indicator and the Composite Tuning Head. The Indicator is a complete spectrum analyzer with a frequency range of 120 to 200 megacycles. The input center frequency of the Indicator is 160 megacycles. The Composite Tuning Head is basically a frequency converter which heterodynes signals in the 10 to 43000 megacycle range to the 120 to 200 megacycle input range required for display on the Indicator CRT.

As the SPA-10 is tuned through its ranges from the low to high ends of the scale, the signals travel across the screen from right to left. They appear as pips of varying amplitudes. The pip directly over the center -0+ CRT screen calibration line represents the signal to which the r-f input is tuned. Because the r-f input has no preselection and is purposely designed for an extremely broadband response, undesired images and harmonics may appear upon the screen. The information contained in paragraph III-2 will aid the operator in determining which are true signals and which are images or harmonics.

b, INITIAL SETTING OF CONTROLS.

Turn the POWER SCALE ILLUM switch to midscale. The CRT baseline

will appear within thirty seconds. Set the front panel controls to the general starting positions given below. (For good stability, a 5 to 10 minute warm-up period is recommended before operating equipment.)

| Control | Setting |
|---|---|
| SPECTRUM CENTERING | Center |
| SWEEP WIDTH | Fully clockwise |
| IF BANDWIDTH | Fully clockwise |
| BRILLIANCE | For desired trace brightness |
| INTENSIFIER | Fully counterclockwise |
| FOCUS | Sharp trace |
| ASTIGmatism | For uniform focus |
| AMPLITUDE SCALE | LINear |
| IF ATTENUATOR toggle switches | Out (down) |
| IF ATTENuator 20 DB (Variable) | 1/16 inch of noise deflection |
| CALibration-SYNChronization SELector | LINE |
| SWEEP RATE | 60 cps |
| SYNCHronization AMPLitude | Approximately 1/4 clockwise (to lock in sweep) |
| VIDEO FILTER | Counterclockwise |
| MARKER FREQUENCY Control | 0 |
| MARKER LEVEL Control | Clockwise to give a one-inch marker pip |
| RANGE | To desired range |
| INPUT | Use appropriate receptacle to connect signal source of antenna lead (refer to table 1-3). |

| | |
|---|---|
| INTERNAL CHECK selector switch | Any position |
| TUNING | Adjust the TUNING control until the scale pointer covers the frequency of interest. If the signal frequency is unknown, or a search for unknown signals is being made, refer to paragraph III-2b for appropriate operating techniques. |

NOTE

When viewing the CRT screen, the operator should keep his sight directly in line with the axis of the cathode-ray tube at a distance of approximately fifteen inches. The CRT screen calibrations have been made from this position, therefore, any other viewing position will introduce a parallax error. A convenient method of finding the corrent position is to close one eye and obtain a reflection of the open eye at the exact center of the engraved scale. The correct viewing position is illustrated in figure III-1.

c. LOCATING A SIGNAL OF KNOWN FREQUENCY.

If the specific frequency range of interest is known, set up the spectrum analyzer in accordance with paragraph III-1b. Adjust the TUNING control until the frequency scale pointer indicates the known frequency. Slowly search this portion of the spectrum

in the vicinity of this frequency until the signals of interest appear on the screen. The exact frequency of the signal can be read on the frequency scale only when the signal is directly over the -0+ calibration on the CRT scale.

d. HOW TO READ THE FREQUENCY SCALES.

A different set of calibrated scales is illuminated for each position of the RANGE selector switch. Within this illuminated scale area, the pointer indicates the exact frequency (within $\pm$ 1 per cent or $\pm$ 1 megacycle, whichever is greater) of the signal appearing at the center -0+ calibration line of the CRT scale. When the frequency to be viewed appears on both illuminated scales, the pointer should be positioned over the frequency reading on the lower illuminated scale for the best sensitivity.

III-2. FREQUENCY DETERMINATION, PANORAMIC SPECTRUM ANALYZER, MODEL SPA-10

a. SPURIOUS SOURCES.

Spurious responses may appear on the face of SPA-10 CRT because of the borad-band design of the input section of the analyzer. Care must be taken, therefore, to ensure that true signals are being displayed. The six general types of spurious responses are as follows:

1. Intermediate-frequency Feed-Through at 160 Megacycles.

This source is easily recognized. The resultant pip will not move across the CRT screen as the TUNING control is adjusted. The signal will behave like an injected marker signal. No harmonic or image response will be generated by this type of signal.

2. Input Signals with Amplitudes Greater (more positive than -40 dbm.

The -40 dbm limitation applies both to signals displayed on the screen and to signals (harmonics) outside the tuned spectrum. For example, injecting a -10 dbm signal at 100 megacycles may cause harmonics of 100 megacycles to be generated in the input mixer, and thus produce a spurious signal pip on the CRT at 2000 megacycles.

3. Spurious i-f Amplifier Signals..

Spurious in-band signals may be generated in the i-f amplifiers when the i-f ATTEN 20 DB control is positioned to cause the signal pip amplitude to exceed a full scale reading.

4. Narrow, High Amplitude, Mixer Pulses.

Very narrow pulse signals (in the order of .01 microseconds) of high amplitude will produce a video pulse in the input mixer, The detected video pulse contains spectral energy which is accepted directly by the 160 megacycle i-f. Figure III-2 illustrates the spectrum of a .01 microsecond pulse. Note that 70 per cent of the second lobe falls within the i-f "acceptance slot" of the Indicator and would appear as a stationary display across the full width of the CRT screen.

5. Local Oscillator Image and Harmonic Responses.

The origin and frequency of an unidentified pip are determined as follows:

(a) Adjust the controls for an 80 megacycle CRT presentation as shown in table III-1.

Table III-1. Control Adjustments for Unidentified Pip

| Step | Control | Setting |
|---|---|---|
| 1 | MARKER LEVEL | Adjust for a 1/2 to full scale pip. |
| 2 | MARKER FREQUENCY | Adjust for a MEGACYCLES dial reading of +40. |
| 3 | SWEEP WIDTH | Turn to position the marker pip at the +0.5 vertical screen calibration. |
| 4 | MARKER-FREQUENCY | Adjust for a MEGACYCLES dial reading of -40. The marker pip should be approximately at the -0.5 vertical screen calibration. |

(b) Adjust the TUNING control to a position which places the signal pip being investigated at the +0.5 CRT screen calibration. Note the frequency indicated by the tuning scale pointer. (Use lower illuminated scale.) Adjust the TUNING control to a position which places the signal pip being investigated at the -0.5 CRT screen calibration. Note the frequency indicated by the tuning scale pointer. (In order to minimize the possibility of error due to mechanical backlash, obtain both tuning scale readings by turning the TUNING control in the same direction.) Calculate and record the difference between the two frequencies.

(c) Calculate and record the order of the harmonic of the local oscillator producing the signal pip being investigated by

the following equation.

$$(1)\quad n = \frac{\text{sweep width}}{f_{diff}} \qquad N=1,2,3\ldots$$

Where n = order of harmonic of local oscillator producing pip.

$f_{diff}$ = difference in frequency between tuning dial settings.

Check whether the pip is a "non-image" or "image" type pip by comparing the direction of pip travel with respect to the direction of travel of the tuning scale pointer. If the pip moves in the same direction as the pointer, the pip is an image. If the pip moves in the direction opposite to dial pointer travel, the pip is a "non-image" type.

(d) If the pip is a "non-image" type, calculate the frequency of the origin of the signal with the following equation:

$$(2)\quad f_x = nf_{dial} + (n-1)\ 160$$

Where: $f_x$ = frequency of the origin of the unknown signal in megacycles

$f_{dial}$ = tuning dial reading when signal being investigated is at the center of CRT screen ($f_{dial}$ read on lower scale of double scales)

n = order of harmonic of local oscillator producing pip.

(e) If the pip is an "image" type, calculate the frequency of the origin of the signal using the following equation:

$$(3)\quad f_x = nf_{dial} + (n+1)\ 160$$

(f) Turn the TUNING control to the calculated signal fre-

quency. The signal pip should appear on the CRT screen. Recheck that the pip is a "non-image" type (pip travels direction opposite to pointer travel as TUNING control is turned and that n=1 (see equation 1). In rechecking use the scale (upper or lower) containing the frequency calculated for $f_x$ to check that n = 1. Errors can occur in the foregoing method because of the rounding off of "n" to the nearest integer when "n" is a large number (4 or above). If a signal pip does not appear at the calculated place, or if a pip with an incorrect value of "n" appears, repeat and recheck the foregoing procedures. Also try values of "n" one below or one above the value originally calculated.

(g) As a final check, an absorption type wavemeter can be used. A wavemeter should be inserted between the signal source and the input as shown in figure III-3.
The wavemeter will produce a slight dip in pip amplitude when it is tuned to the correct frequency. However, the preceeding procedures of paragraph III-2 should be completed first. An attempt to use a wavemeter to measure signals outside the frequency range of the wavemeter could produce spurious responses which could lead to false conclusions regarding the frequency of the signals being investigated.

6. Identification of First Mixer Harmonics of the Signal.
Once it has been determined that the pip on the screen is caused by the fundamental (or correct harmonic) of the local oscillator,

the possibility that the pip is some harmonic of a lower frequency signal can be checked. This harmonic can be caused by the input signal overloading the input mixer, or it can be a true component of the input signal. In either case, the fundamental signal can be found by tuning to the various subharmonics (1/2, 1/3, 1/4, etc.) of the dial frequency and searching for signals. If it is necessary to determine the source of the harmonic, any of the following procedures can be tried:

(a) Insert a known large amount of attenuation between the signal source and the spectrum analyzer. Use an attenuator which operates in the frequency of both thefundamental and the harmonic. If the harmonic decreases as much as the fundamental, then the harmonic is a signal component. If the harmonic decreases at a much greater rate than the fundamental, the harmonic is produced in the input mixer of the analyzer .

(b) A high pass filter can be inserted between the signal source and the spectrum analyzer. This would eliminate the fundamental but have negligible effect on the harmonic. Therefore, if the harmonic is not eliminated, it is a signal component; if the harmonic is eliminated, it is created in the input mixer.

(c) A wavemeter can be inserted in the signal path. If the harmonic produces a wavemeter dip at the harmonic frequency, then the harmonic is a signal component. It is well to check that the wavemeter does not cause a dip at the fundamental frequency when the wavemeter is tuned to the harmonic.

b. EXAMPLE OF FREQUENCY DETERMINATION.

In searching for spurious signals from an oscillator, assume that a pip is discovered at 350 megacycles. The following steps would be taken if it were desired to determine the true signal frequency.

1. Adjust the SWEEP WIDTH control for an 80 megacycle sweep width. Use the marker pip to set up the 80 megacycle sweep width presentation.

2. If the signal pip moves in the same direction as the tuning scale pointer when the TUNING control is turned, then the pip is caused by an image signal.

3. The pip should then be positioned at the +0.5 vertical screen calibration with the TUNING control. At this time, the tuning scale pointer should read 359.5 megacycles.

4. The pip should then be positioned to the -0.5 vertical screen calibration. The tuning scale pointer should now read 340.5 megacycles.

5. n (harmonic order) is determined through use of the following equation:

$$n = \frac{80}{359.5 - 340.5} = \frac{80}{19} = 4.2 \approx 4$$

6. The input signal frequency is calculated with the following "image equation".

$$f_x = nf_{dial} + (n+1)\ 160$$

$$f_x = 4\ (350) + 5\ (160) = 2200 \text{ megacycles}$$

7. Assume that the TUNING scale pointer has been adjusted to read 2200 megacycles and that a pip appears on the CRT screen.

8. When the TUNING control is turned slightly, the pip moves in a direction opposite to the tuning scale pointer travel. This action indicates that the pip is not produced by an image.

9. When the pip is positioned to the -0.5 CRT screen calibration the tuning scale pointer reads 2240 megacycles.

10. The pip is then positioned to the +0 5 CRT screen calibration. The tuning scale pointer now reads 2165 megacycles.

11. 2240 megacycles minus 2165 megacycles equals 75 megacycles. This answer is close enough to 80 megacycles to show that 2200 megacycles is the actual frequency of the signal. The following equation is used in obtaining dial frequencies at other places which would be caused by the 2200 MC signal.

$$f \text{ dial} = \frac{f_x - (n \pm 1)\ 160}{n} = \frac{2200 - (n \pm 1)\ 160}{n}$$

The following list of image and non-image frequencies have been calculated with a constant non-image fundamental (2200 megacycles) and with various values of n.

| N Value | "Non-Image" Harmonic Pips | "Image" Harmonic Pips |
|---|---|---|
| 1 | 2200 megacycles | 1880 megacycles |
| 2 | 1020 megacycles | 860 megacycles |
| 3 | 627 megacycles | 520 megacycles |
| 4 | 430 megacycles | 350 megacycles |
| 5 | 312 megacycles | 248 megacycles |
| 6 | 233 megacycles | 180 megacycles |

| N Value | "Non-Image" Harmonic Pips | "Image" Harmonic Pips |
|---|---|---|
| 7 | 177 megacycles | 131 megacycles |
| 8 | 154 megacycles | 95 megacycles |
| 9 | 102 megacycles | 66 megacycles |
| 10 | 76 megacycles | 44 megacycles |
| 11 | 54.5 megacycles | 22.5 megacycles |
| 12 | 36.6 megacycles | 10 megacycles |
| 13 | 21.5 megacycles | -- megacycles |

These signals will appear on the Indicator when a 2200 megacycle input is present. Unless the 2200 megacycle signal is suppressed, all the frequencies listed (except 2200 megacycles) should be disregarded in a search for additional signals.

Note that all the pips produced by the mixing of an input signal with harmonics of the local oscillator fall at points on the tuning scale below the true input frequency. For this reason it is good practice, when searching for unknown signals, to start at the highest frequency of interest and search downward in frequency.

c. FREQUENCY MEASUREMENTS TO AN ACCURACY OF 1 PER CENT.

Once the approximate frequency of a signal is known and it is required to measure the frequency to the 1 per cent accuracy of the SPA-10, the following procedure should be used.

1. Adjust the SWEEP WIDTH control to obtain a sweep width of a few megacycles.

2. Adjust the MARKER FREQUENCY control to obtain a zero reading on the MEGACYCLES dial.

3. Adjust the MARKER LEVEL control to produce a full scale marker pip.

4. Adjust the TUNING control until the signal pip coincides with the center of the marker pip.

5. Read the exact frequency on the tuning scale.

III-3. AMPLITUDE MEASUREMENTS

a. GENERAL.

The relative strengths of displayed signals are indicated by the respective heights of each pip. Selection of logarithmic, linear or power (square law) amplitude presentation is made with the AMPLITUDE SCALE selector switch.

1. In the LIN position of the AMPLITUDE SCALE selector switch, the right hand (VOLTAGE) Indicator screen calibrations from 0 to 1.0, which correspond with the horizontal lines, are used. These are direct relative voltage calibrations. A signal at half scale (0.5 horizontal line) is one half the voltage (6 db down) of a signal at full scale (1.0 horizontal line).

2. In the LOG position of the AMPLITUDE SCALE switch, the left hand (LOG DB) Indicator screen calibrations are used. The CRT screen is calibrated with dots along the left hand side in 5 db graduations. 0 DB corresponds to the top (1.0) horizontal line, -20 DB corresponds to the center (0.5) horizontal line and -40 db corresponds to the 0.1 (next to the bottom) horizontal line. Thus the LOG position of the AMPLITUDE SCALE switch provides a three point calibration.

A signal at half scale is 20 db down (1/10 in voltage, 1/100 in power) from a full scale signal.

3. In the PWR position of the AMPLITUDE SCALE switch, the calibrations on the right hand side of the Indicator CRT (0 to 1.0) are used but are read directly in power. A signal at half scale (0.5) is half power (3 db down, 70 per cent in voltage) from a full scale signal .

b. FLATNESS.

In the SPA-10, flatness is defined as the total variation in db of amplitude response of a signal pip as a signal input of constant amplitude is varied over a given frequency band. The overall flatness of Model SPA-10 is the algebraic sum of the flatness of the first i-f amplifier bandpass (80 megacycles) plus the flatness of the Tuning Head input circuits. Typical i-f flatness curves are shown in figure III-4.

NOTE

When i-f flatness measurements are taken, a 3 db or 6 db pad in series with the signal source should be connected to the DIRECT INPUT to provide a termination for the r-f cable in use

NOTE

i-f flatness will change somewhat with line voltage due to filament variation.

In general, because the response of the input circuitry is relatively flat over any selected 80 megacycle spectrum segment, the total response of the SPA-10 does not differ materially from the i-f response. Although the design specifications of the SPA-10 i-f flatness is 3 db, the usual result is somewhat better than ± 1-1/2 db over most of the r-f range. However, at a few discrete frequencies, it is possible that, due to crystal resonance or mismatches, there will be a dip in the input section response, which combined with the i-f response, will yield a total flatness greater than 3 db.

c. RELATIVE AMPLITUDE MEASUREMENT.

This paragraph presents the method for measuring the relative amplitudes of two discrete signals having dispersions of 80 megacycles or less.

1. Connect the signals to be measures to the appropriate input jack on the Tuning Head. Use r-f padding between the input frequency source and the Tuning Head input jack.

NOTE

When the amplitude of the input frequency is extremely small, further signal attenuation from r-f impedance matching pads may prove impractical. r-f padding, however, should be used whenever possible.

2. Adjust the SWEEP WIDTH control to a point where a minimum sweep width adjustment displays the signal of interest on the CRT.

3. Set the AMPLITUDE SCALE selector switch to the desired position.

4. If required, adjust the IF BANDWIDTH control for best resolution. (Refer to paragraph II-3h for adjustment of this control).

5. Adjust the IF ATTEN 20 DB control so that the largest signal pip present on the CRT screen is exactly full scale.

6. Read the relative amplitudes of the signal pips. (The accuracy of the relative amplitudes is approximately 3 db). Flatness accuracy increases as the sweep width is reduced.

7. For more accurate measurements it is necessary to make a flatness curve for the frequency range of interest. The flatness curve, which indicates the amplitude relationship of frequencies shown on the CRT, can be used for calibration purposes. Two methods of producing a flatness curve are as follows:

(a) A rough flatness curve can be made by marking the spot on the face of the CRT at which each individual frequency peak occurs. Adjust the TUNING control so as to cause the largest signal present to move back and forth across the full width of the Indicator screen. The top of the CRT signal at each position of the TUNING control represents the flatness curve. Adjust the IF ATTEN 20 DB control so that the highest point traced by the top of the pip is at full scale. Using a grease pencil, mark the curve traced by the top of the pip while adjusting the TUNING control for a frequency sweep across the Indicator CRT.

(b) An accurate flatness curve can be marked on the Indicator screen by using an external signal generator. Connect a signal at the frequency of interest to the appropriate input jack. Keep the signal generator output level constant. Vary the frequency of the signal generator over the required range. If a long cable is normally used to connect signal being investigated to the SPA-10, the same length of cable must be used to connect the signal generator being used for calibration.

8. The i-f flatness response of each signal should not have more than 3 db deviation in amplitude across any 80 megacycle spectrum of the CRT as the tuning pointer is moved across the dial scale. a gradual change in signal amplitude is considered to be a change in sensitivity while an abrupt up and down change is considered to be a "hole". If a "hole" greater than 6 db is encountered, the response may be improved through the use of more accurate impedance matching devices between the signal generator output and the spectrum analyzer input jacks. Another method of improving circuit response is to adjust the crystal bias .

CAUTION

The crystal bias adjustment should be performed only if the frequency of concern is used extensively. It is possible that crystal bias adjustment for only one frequency may have an adverse effect on

the response of other frequencies throughout the spectrum. Before adjusting the crystal bias, record the crystal bias voltage indication of the internal check meter. At the completion of monitoring this particular frequency, return the crystal bias to its original level.

d. MEASUREMENT OF ABSOLUTE AMPLITUDE.

1. Connect the input signals to the appropriate jack on the Tuning Head. Adjust the IF ATTENUATOR so that the largest signal pip present on the CRT screen is exactly full scale.

2. Remove the input signal. Without altering the settings of the Model SPA-10 controls, inject a signal of the same frequency from an external signal generator. Adjust the attenuator of the signal generator to provide a full scale pip at the center of the CRT screen.

3. Read the absolute amplitude of the signal of interest on the attenuator of the signal generator.

4. Repeat steps 1, 2, and 3 for each signal of interest.

e. RELATIVE MEASUREMENT OF SIGNALS WITH FREQUENCY SEPARATION GREATER THAN 80 MEGACYCLES.

Due to variation in flatness response of the Tuning Head over any one frequency range, or from one range to another, only absolute

amplitude measurements of widely dispersed signals are possible. True relative amplitude measurements can only be made when both signals are present on the CRT screen at the same time.

f. SEARCH FOR LOW LEVEL SIGNALS.

The detection of low level signals involves a compromise between the method used in obtaining maximum analyzer sensitivity (refer to paragraph II-4e for sensitivity check) and the analyzer adjustment performed for a "fast search" of a signal. Maximum analyzer sensitivity occurs at very narrow sweep widths of approximately one kilocycle. However, under this ideal condition, the operator would have to use extreme care in observing the CRT for a weak signal while, at the same time, slowly adjusting the TUNING control. A practical test signal is easiest to locate on the CRT when the sweep width is 80 megacycles and the i-f bandwidth is 80 kilocycles. The difference between the maximum and minimum sensitivity measurements is approximately 20 db. Therefore, for easier initial location of a test signal, a compromise test set up within the 20 db difference area has been found to be most practical. The control settings for detection of low level signals are as follows:

1. CW, AM, or FM Modulated Signals

| Control | Setting |
|---|---|
| SWEEP WIDTH | Approximately 5 megacycles (determine by marker setting) |
| CALibration SYNChronization SELector | LINE |

| Control | Setting |
|---|---|
| SWEEP RATE | 15 cps - (4 sine waves) |
| VIDEO FILTER | Turn to a position where noise just begins to be eliminated. |
| AMPLITUDE SCALE | LINear |
| IF BANDWIDTH | Fully counterclockwise |
| IF ATTEN 20 DB | 1/4 inch noise on CRT |

Set other controls as desired. Slowly turn the TUNING control through the frequency range of interest. This procedure should give a sensitivity of approximately 10 db lower than maximum, but still permit a rapid tuning search.

2. Pulse Signals

| Control | Setting |
|---|---|
| SWEEP WIDTH RANGE | Approximately 5 megacycles (determine by marker setting) |
| CALibration SYNChronization SELector | LINE |
| SWEEP RATE | 15 cps (4 sine waves) |
| VIDEO FILTER | Counterclockwise |
| AMPLITUDE SCALE | LINear |
| IF BANDWIDTH | Fully Counterclockwise |
| IF ATTEN 20 DB | 1/4 inch noise on CRT |

Set other controls as indicated in paragraph III-1b. Slowly turn the TUNING control through the frequency range of interest. This procedure is the best method of searching for pulse signals in the

order of .5 to 10 microseconds pulse-widths and repetition-rates of a few hundred pulses per second to a few thousand pulses per second.

g. MEASUREMENT OF HARMONIC RESPONSES.

1. To measure the harmonic response of a known fundamental frequency, connect the signal under examination to the appropriate jack on the Tuning Head. Adjust the TUNING control to obtain the fundamental frequency of the input signal on the CRT screen. Adjust the IF ATTEN 20 DB control for a full scale deflection of the signal on the CRT.

2. Remove the input signal. Without altering the settings of the SPA-10 controls, connect an identical frequency from an external signal generator to the appropriate jack on the Tuning Head. Adjust the attenuator of the signal generator for a full scale pip deflection . The reading on the signal generator should not be greater than -40 dbm.

3. Reconnect the signal under examination to the appropriate jack on the Tuning Head. Adjust the TUNING control until the harmonic frequency under consideration appears at the tuning scale pointer and on the CRT screen.

4. Adjust the IF ATTEN 20 DB control for a full scale deflection of the harmonic signal on the CRT. Remove the input signal. With

out altering the settings of the SPA-10 controls, connect an identical frequency from an external signal generator to the appropriate jack on the Tuning Head. Adjust the attenuator of the signal generator for a full scale pip deflection. the reading on the signal generator should not be greater than -40 dbm.

5. Refer to the procedure in paragraph III-2a. for identification of first mixer harmonics. It should be determined whether the harmonic response is a true multiple of the signal or whether it is generated within the spectrum analyzer. If the fundamental input signal is kept below -40 dbm, however, the spectrum analyzer should produce no visible harmonic responses.

h. RESPONSE OF A SPECTRUM ANALYZER TO PULSED RF SIGNALS.

The response of a spectrum analyzer to pulsed r-f signals has been analyzed in detail by many groups; an especially informative discussion on this subject is contained in the Radiation Laboratory Series, Volume II, "Technique of Microwave Measurements", Chapter 7, entitled "The Measurement of Frequency Spectrum and Pulse Shape." This analysis deals with very short pulses ranging from 0.1 microsecond to several microseconds and with a relatively long time interval between pulses. In general, the i-f amplifier of the spectrum analyzer is narrow compared to the reciprocal of the pulse width but is still sufficiently broad so that the transient gener$_a$-

ted by a pulse has decayed entirely before the next pulse occurs. The analyzer shows that there is a loss in response of an analyzer between cw signals and pulsed signals due to the fact that the required cw i-f bandwidth is narrow compared to the bandwidth necessary to transmit a pulse without distortion. The response of the analyzer to a pulsed signal is:

$$e = \frac{A\ 3\ \tau\ (\Delta f)}{2} \quad , \text{ where } \tau\ (\Delta f) \leq .1$$

Where A = response to a cw signal in volts

$\tau$ = r-f pulse length (rectangular pulse)

$\Delta$ = 3 db down i-f bandwidth

e= voltage response to a pulse

For example, it was found that there was no response by the analyzer to a 0.1 microsecond pulse at 38 kmc. The sensitivity of the analyzer to a cw signal with the IF bandwidth adjusted to minimum (1 KC) was -55 dbm. In case of a 0.1 microsecond pulse and a bandwidth of 80 KC

$$e = A\ \frac{(3)}{(2)}\ (.1 \times 10^{-6})\ (80 \times 10^{3}) \quad = .012A$$

This corresponds to a loss of approximately 38 db.

In addition, the noise is increased from that obtained when measuring the cw tangential sensitivity at a 1 KC bandwidth, due to the fact that we are now using the analyzer at an 80 KC i-f bandwidth. The increase in noise voltage is proportional to the square root of the

bandwidth, or about 19 db additional noise. Therefore, the tangential sensitivity of the analyzer to a 0.1 microsecond pulse is: -55 + (19 + 38) or +2 dbm. Any signal greater than approximately -10 dbm would overload and block the input crystal thus the analyzer would be inoperative. This -10 dbm signal would therefore be 12 db below the noise. A good spectrum contains a signal to noise ratio of about 20 db. Therefore, a -10 dbm input level with a 0,1 microsecond pulse frequency requires an increase in sensitivity of about 32 dbm.

III-4. NARROW BAND ANALYSIS.

At full sweep width, test signals, or a carrier and its sidebands having a small frequency difference, tend to have their adjacent deflections merge and thus mask each other. (See figure III-5a) These deflections may be separated (resolved) by increasing the scanning time (reducing the sweep rate), by narrowing the i-f bandwidth with the sweep rate and/or by reducing the sweep width. (See figure III-5b.)

a. USE OF THE VARIABLE IF BANDWIDTH CONTROL.

The variable IF BANDWIDTH control varies the i-f bandwidth of the third (6 5 mc) i-f amplifier. This control is used to separate closely spaced signals, achieve optimum resolution of signals, to improve the signal to noise ratio of low level signals, or to improve the definition and brightness of pulse displays. Waveforms (a) through (f) of Figure III-6 illustrate progressive variations

in pip width caused by counterclockwise rotation of the IF BANDWIDTH control. The amount of ringing in (d) shows optimum resolution. Relative amplitude measurements of two adjacent signals can be made when the two signals are completely resolved. This separation can be accomplished by the use of the IF BANDWIDTH CONTROL. Figure III-7 (a) through (e) illustrates the progressive separation of closely spaced signals of equal amplitude. If a signal of small amplitude is close in frequency to a signal of large amplitude, the pip representing the small amplitude signal will be influenced by the large amplitude signal. As the signals separate in frequency, the error becomes less. Waveforms (a) through (f) of figure III-8 illustrate the progressive variation in pip separation of two signals as the i-f bandwidth is narrowed.

b. INCIDENTAL FM.

Incidental FM will appear as a band of frequencies on the Indicator CRT. This spectrum display is caused by a line frequency ripple in the klystron reflector supply Incidental FM occurring at a fast sweep speed is shown in figure III-9a; figure III-9b shows incidental FM at slower sweep speeds.

c. VIDEO FILTER.

The adjustable VIDEO FILTER control is used to smooth or suppress unwanted effects on the CRT such as noise and spurious beating

between adjacent signals. A signal with the VIDEO FILTER control turned counterclockwise is shown in figure III-10a. The same signal is shown with the VIDEO FILTER control turned fully clockwise (figure III-10b). Figure III-10c shows the CRT presentation with the VIDEO FILTER control at mid-position.

d. USE OF THE INTENSIFIER CONTROL.

The INTENSIFIER control should be turned in a more clockwise direction when pulsed signals are to be observed. Noise and pulsed signals will then modulate the CRT beam. Incorrect setting of the INTENSIFIER control will cause washout of portions of pulsed signals. Figure III-11a, b, and c, illustrate the effects of (a), a lack of intensity; (b), correct intensity; and (c), over intensity.

III-5. INTERPRETATION OF VARIOUS SPECTRAS.

The following paragraphs present various types of CRT presentations with associated data. With a little experience,the operator should recognize these waveforms as representing specific types of input signals.

a. AM SIGNALS.

An unresolved amplitude modulated carrier of low frequency appears as a single deflection of variable height on the CRT. The higher the a-m input frequency, the easier the sidebands can be separated from the marker frequency and therefore, the better the resolution

on the CRT. Figure III-12a shows the marker (in center) and the sidebands of a modulating frequency. Figure III-12b shows the marker and the sidebands of a higher modulating frequency. As the modulation frequency increases, the sidebands move away from the carrier frequency (marker pip). Sideband separation can also be obtained by turning the SWEEP WIDTH control counterclockwise. The positioning of the sidebands with the SWEEP WIDTH control however has no effect on the frequency span between the sidebands. If the relative heights of the sidebands vary as the TUNING control is turned, this effect is due to incidental FM.

b. BALANCED MODULATION.

The SPA-10 Spectrum Analyzer can be used as an aid in adjusting balanced modulators for minimum transmission of the carrier. This adjustment can be accomplished merely by tuning the spectrum analyzer to the carrier frequency of the unit under test. With the use of the balance control on the balanced modulator, adjust the carrier pip for minimum height on the Indicator CRT Balanced modulation will appear as shown in Figure III-13.

c FM SIGNALS.

In frequency modulation, the instantanious carrier frequency varies in accordance with the amplitude of an audio modulating signal. Simple sine wave FM can be studied mathematically, but when using

the SPA-10, differences between the predicted structure and the actual spectrum can be viewed on a CRT screen and then analyzed. Frequency modulated signals, when viewed on the Indicator CRT appear as a series of vertical deflections. Figure III-14a shows FM modulation with sidebands resolved. (The frequency difference from one pip to the next is the audio frequency). The carrier is balanced out. Figure III-14b shows the same FM signal, with the sidebands unresolved.

d. PULSE SPECTRA.

A chief use of the spectrum analyzer is to check the operation of pulse-modulated transmitters. It is used to advantage as a sensitive indicator in checking for excessive frequency modulation of a pulse signal. Excessive frequency modulation tends to remove power from the central lobe of the pulse.

In addition, excessive frequency modulation broadens the pulse thus placing excessive power into the side lobes. (See figure III-15). Figure III-15a illustrates spikes, indicating distribution of a pulsed r-f signal. Figure III-15b shows the same signal at a slower sweep speed.

III-6. TYPICAL TEST APPLICATIONS

This section outlines some typical tests performed on radar transmitters and other microwave equipment with the SPA-10 Spectrum Analyzer.

a. USED AS A SENSITIVE RECEIVER.

Due to the high sensitivity of the SPA-10 Spectrum Analyzer, this unit can be used to advantage as a sensitive receiver capable of performing many tests, calibrations and measurements, some of which are listed as follows:

1. Insertion Loss Measurements. To measure for insertion loss at any particular frequency, use the test set-up shown in figure III-16.

(a) Set the SPA-10 controls as listed in paragraph III-1b. Turn the MARKER LEVEL control to the OFF position.

(b) Adjust the TUNING control until the signal appears on the CRT screen. If the network under test has a high insertion loss (in the order of 40 to 100 db) adjustment of the SWEEP WIDTH, IF BANDWIDTH, and IF ATTEN 20 db controls may be necessary to ensure maximum sinsitivity of the SPA-10. (Refer to paragraph II-4e). Adjust the signal generator for maximum calibrated output power.

(c) Adjust the signal generator for a full scale signal on the Indicator CRT. Note the signal generator dbm output level.

(d) Remove the network under test as shown in figure III-17,

(e) Reduce the signal generator level to produce a full scale signal on the Indicator CRT. Note the new signal generator dbm output level.

(f) The difference in power level between the readings in step (c) and (e) is the insertion loss at the specific frequency.

(g) Repeat the preceeding procedure for as many frequencies as desired. In this way, frequency response curves over large

frequency ranges can be obtained.

2. Large variations in Response over Small Frequency Ranges.

These frequency variations can be observed on the CRT as follows:

(a) Set the SPA-10 controls as listed in paragraph III-1b. Turn the MARKER LEVEL control to the OFF position.

(b) Adjust the TUNING control until the signal appears on the CRT screen. If the network under test has a high insertion loss (in the order of 400 to 100 db) adjustment of the SWEEP WIDTH, IF BANDWIDTH and IF ATTEN 20 DB controls may be necessary to ensure maximum sensitivity in the SPA-10.

(c) Adjust the signal generator for maximum calibrated output power.

(d) Set the AMPLITUDE SCALE selector switch to the LOG position.

(e) Keeping the signal generator output level constant, vary the frequency. The top of the signal pip on the CRT will trace out the response curve of the unit under test.

(f) If very accurate measurements are required, it may be necessary to use the test set-up shown in figure III-17 and repeat step III-6a1. This will check the response of the system, without the test network, for flatness. If this response is not flat, the pip will trace out the correction curve of the system.

3. VSWR Measurements. VSWR measurements can be made by using the SPA-10 as a sensitive receiver in conjunction with a signal generator, matched pad and a slotted line. Use the following procedure.

(a) Connect the test set-up as shown in figure III-18.

(b) Set the SPA-10 controls as listed in paragraph III-1b. Turn the MARKER LEVEL control to the OFF position.

(c) Connect the probe to the appropriate input connector on the SPA-10.

(d) Vary the probe back and forth over the slotted line and note the variations in amplitude on the Indicator CRT. The degree of change between maximum and minimum signal amplitude will indicate the VSWR. See figure III-19.

3. Wavemeter Calibration

(a) The SPA-10 Spectrum Analyzer can be used in the calibration of the wavemeters as a sensitive detector. A transmission cavity can be tuned for maximum deflection of the marker pip on the CRT.

(b) When tuning a cavity, tune for a minimum deflection of the marker pip on the Indicator CRT. Use the test set-up shown in figure III-20.

b. VISUAL FREQUENCY COMPARISON.

Visual frequency comparison between a standard frequency and a

frequency of interest can be achieved by using the SPA-10 as a sensitive indicator. Use the following procedure.

1. Connect the test set-up shown in figure III-21.

2. Set the SPA-10 controls as indicated in paragraph III-1b. Turn the MARKER LEVEL control to the OFF position.

3. Adjust the TUNING control until the standard frequency signal appears at the center of the Indicator CRT.

4. Adjust the controls on the unit under test so that its signal appears on the Indicator CRT alongside or superimposed with the frequency signal standard.

c. FILTER RESPONSES.

Filter responses can be determined by using the SPA-10 spectrum analyzer in conjunction with a signal generator.

1. One method of checking filter responses is to set the signal generator to a known frequency and connect it to an analyzer input jack. Adjust the input signal level to obtain a reference point on the Indicator CRT. A check should be made at this time to observe the flatness response of the spectrum analyzer. When this has been accomplished, connect the signal generator to the input of the filter under test and connect the output of the filter to a spectrum analyzer input jack. Slowly sweep the input frequency range of the spectrum analyzer while keeping the signal level constant; the response on the CRT will be within the frequency range of the filter response. Refer to figure III-22 and figure

III-23 for the filter response and the filter response test set-up.

2. Another method of checking filter responses is the Insertion Loss method.

This is accomplished by setting the signal generator to a known frequency and setting the amplitude to a reference point on the CRT. Keeping the signal generator set at this frequency and amplitude, insert the filter to be tested in series with the signal generator and the spectrum analyzer. The response on the CRT will deviate from the reference point. By repeating these steps, changing only the frequency input and keeping the level constant at the reference point on the screen, the technician can plot the filter response curve. (Refer to paragraph III-6a1).

d. SIGNAL FREQUENCY STABILITY MEASUREMENTS

1. When measuring for short term stability, use the following procedure:

(a) Set the SPA-10 controls as listed in paragraph III-1b.

(b) Place the unit under test to its normal operating environment.

(c) Connect the signal to be tested to the appropriate INPUT connector on the SPA-10.

(d) Adjust the TUNING control until the signal under test appears on the Indicator CRT.

(e) Adjust the SWEEP WIDTH control in conjunction with the MARKER FREQUENCY control until the marker pip is in line with the signal pip. Note the MARKER FREQUENCY dial setting.

(f) Change the environment of the unit under test to a predetermined level and note the frequency shift.

(g) Adjust the MARKER FREQUENCY control until the marker pip is in line with the frequency shift. Note the marker dial setting. The difference in the MARKER FREQUENCY settings of steps (e) and (g) will indicate the frequency shift of the unit under test.

2. When measuring for long term stability, the use of an external crystal marker is advisable. Although the SPA-10 is a versatile and accurate test instrument, its marker oscillator is not crystal controlled, therefore, it cannot be considered extremely stable over long periods of operation. In performing long term stability checks, use the same procedure as given for short term stability checks. The difference , however, is that the external crystal marker should be used in place of the SPA-10 marker.

3. Microphonics can be viewed on the SPA-10 Spectrum Analyzer by performing the following procedure:

(a) Set the SPA-10 controls as listed in paragraph III-1b. Turn the MARKER LEVEL control to the OFF position.

(b) Connect the signal to be tested to the appropriate input connector on the SPA-10.

(c) Adjust the TUNING control until the signal under test appears at the center of the Indicator CRT.

(d) Adjust the SWEEP WIDTH control until a suitable display of the signal is present. Microphonic content can be identified as noise or distortion of the signal under test. See figure III-24.

4. Squegging. Squegging of an oscillator can be defined as recurrent interruptions of oscillations at an audio or r-f rate. Since the spectrum of squegging in an oscillator resembles the spectrum of a pulse-modulated wave, the squegging presentation contains sideband components in addition to the oscillator frequency. The output of a continuous oscillator can, therefore, be viewed for squegging as well as spectral purity.

5. Spurious Signals. See Section III - 2 (Frequency Determination). The SPA-10 Spectrum Analyzer can be used to locate spurious signals of oscillators, amplifiers, and transmitters. This can be accomplished by first formulating a chart of the known frequencies of the equipment under test. Then, by using a filter, to filter out the known input frequency to the spectrum analyzer, the technician can observe various remaining frequencies on the CRT and seek out the spurious signals. Spurious signals will be those signals which appear on the CRT but which are not on the formulated chart of known freqiemcies of equipment under the test.

6. Indcidental FM. The following procedure is a quick method of checking for incidental fm in the circuits following the marker oscillator in the SPA-10 Spectrum Analyzer. This method presents a useful calibration technique but should not be considered as extremely accurate.

Preliminary Set-up

(a) Adjust the SWEEP W1DTH control for minimum sweep width (200 KC).

(b) Adjust the IF ATTEN 20 DB control for a 1/16 noise presentation on the Indicator CRT.

(c) Adjust the MARKER FREQUENCY and LEVEL controls for a full scale pip at the center of the CRT.

(d) Set the CAL-SYNC SEL switch to the CAL position.

(e) Turn the SYNC AMPL control fully counterclockwise.

(f) Turn the SWEEP WIDTH control clockwise. This should provide a sine wave display moving to the right on the CRT.

(g) set the CAL-SYNC SEL switch to the EXT position.

(h) Turn the I-F BANDWIDTH control counterclockwise until optimum resolution is obtained.

(i) The width of the jitter of the top of the pip, frequency wise, represents the deviation of the incidental 60 cycle rate FM.

7. FM of an External Signal.

FM contained ina specific signal may be determined by subtracting the indicental FM figure produced by the SPA-10 from the addition of the indicental FM produced by the SPA-10 and the specific signal of interest. This procedure should be performed as follows:

NOTE

It should be noted that the order number of a harmonic is directly proportional to the amount of incidental FM occurring with the harmonic.

(a) Obtain a signal generator known to have a low incidental f-m such as the Hewlett-Packard #608 or #612.

(b) Tune the SPA-10 Spectrum Analyzer to the r-f frequency under test.

(c) Tune the signal generator to the same r-f frequency as the frequency under test. If the desired frequency is too high for the signal generator, use the highest fundamental frequency of the signal generator that will provide a harmonic signal at the desired frequency.

(d) When the signal is obtained at the desired frequency, adjust the deviation of the signal in the same manner as in paragraph III-6,d,6 steps a through h.

(e) Center the marker pip on the Indicator screen and using the audio signal generator to provide sidebands, measure the deviation in the same manner as described in paragraph III-6d6, steps h through k. This will indicate the incidental f-m of the SPA-10 Spectrum Analyzer.

(f) Using the signal under test in the same manner as the signal generator signal, repeat steps (a) through (e). The incidental f-m of the signal under test can then be determined by subtracting the figure obtained in step (e) above, from the figure obtained in step (f). To repeat, the procedure given above is only a quick method of checking incidental f-m. This method will give a useful calibration but should not be considered as extremely accurate.

e. MONITORING OF COMMUNICATION BANDS AND SPILL-OVER.

Due to the high sensitivity of the SPA-10, the spectrum analyzer can be used with great advantage in monitoring communication band spill-over.

1. Monitoring of communication bands can be accomplished by utilizing the Indicator CRT. A check of frequency drift, signal level drop, stability, and modulation characteristics can be quickly analyzed. For locations of further explanation on the various checks mentioned, refer to the table of contents.

2. Spill-Over can be checked by monitoring the output frequency of the equipment under test on the Indicator CRT. By observing the bandwidth of the signal under test, the user can note if the signal is exceeding or spilling over its alloted tolerance.

f. RFI MEASUREMENTS, SPECTRUM SIGNATURES.

1. Spurious outputs of transmitters can be located by using the SPA-10 Spectrum Analyzer as a frequency-selective voltmeter or power measuring device. The following is the procedure used to scan the spectrum as well as locate, measure, and record the spurious output of the transmitter under test.

(a) Connect the test components as shown in figure III-25.

(b) Tune the transmitter under test to a standard frequency.

(c) Set the SPA-10 controls as listed in paragraph III-1b. Turn the MARKER LEVEL control to the OFF position.

(d) Connect the signal under test to the appropriate input connector on the SPA-10. Bypass the fundamental frequency rejection network.

(e) Tune the SPA-10 to the fundamental frequency of the transmitter under test by adjusting the TUNING control until the signal appears on the Indicator CRT.

(f) Connect the Fundamental Frequency Rejection Network as shown in figure III-25. The signal on the CRT should then disappear

(g) Adjust the IF ATTEN 20 DB GAIN control for maximum amplitude.

(h) Adjust the TUNING control for a CRT presentation of the frequency of interest.

(i) When a spurious signal is found, check its frequency by reading the dial scale.

NOTE

Be sure that the spurious responses being measured are not those generated by the SPA-10. Refer to Paragraph III-2.

(j) Adjust the IF ATTEN 20 DB control to obtain a full scale CRT indication of the spurious signal.

(k) Set the coaxial switch to position 2. Set the signal generator level to the same frequency as the spurious signal.

(l) Adjust the signal generator level to obtain a full scale indication of the Indicator CRT.

(m) Record the signal generator level.

(n) Repeat the preceeding procedure. Scan across the entire frequency band of interest until the frequencies and levels of all spurious outputs are located.

2. Various types of spectrum signatures on the CRT can be quickly identified and analyzed. This manual has presented the most common

and more basic types of spectrum signals. These spectrum pictures should enable the user to identify and analyze interfering signals, presence and frequency of r-f signals, modulation characteristics and many other spectrum signatures. The following CRT presentations should be associated with their respective titles.

g. SIGNAL-STRENGTH-METER AND VOLTMETER.

Signal-strength and signal voltage measurements can be obtained with the SPA-10 Spectrum Analyzer as follows:

(a) Set the SPA-10 controls as listed in paragraph III-1b. Turn the MARKER control to the OFF position.

(b) Insert the output of a signal generator, calibrated at 40 dbm into the appropriate input jack.

(c) Set the RANGE selector switch to the position which corresponds to the frequency of the input jack being used. Adjust the frequency TUNING control until the Tuning Head frequency dial reads the same frequency as the signal generator. The signal generator input pip should now appear on the CRT screen.

(d) Disconnect the signal generator. Connect the signal to be measured to the appropriate input. Select, through use of the AMPLITUDE SCALE selector switch, the desired method of signal measurement (LOG - LIN - PWR). Refer to paragraph III-3 for signal strength and voltage measurements.

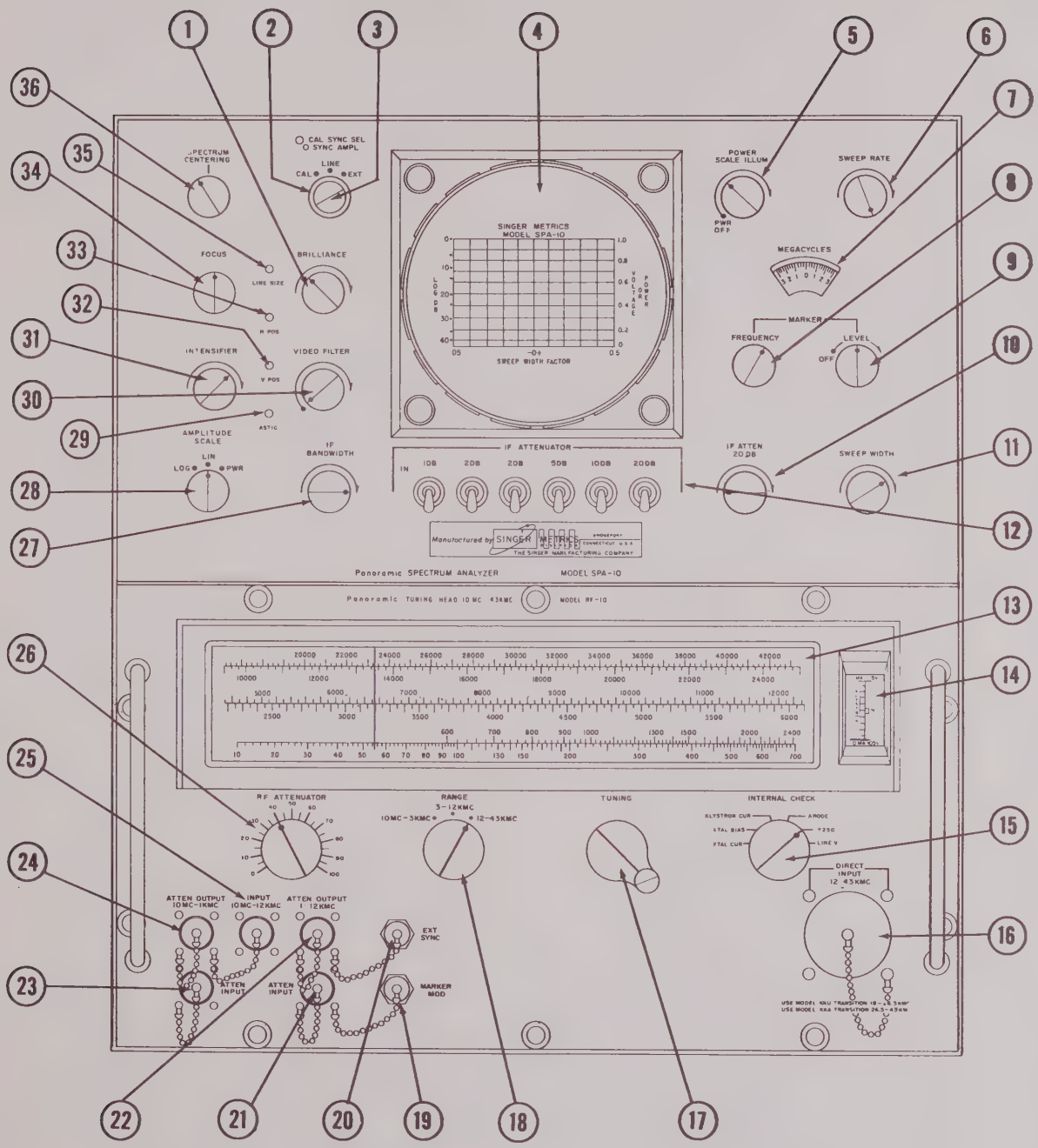
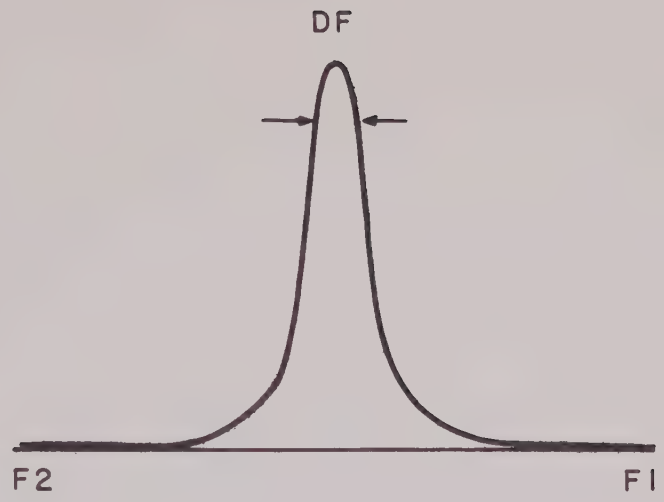



Figure I-1. Spectrum Analyzer SPA-10 Front Panel



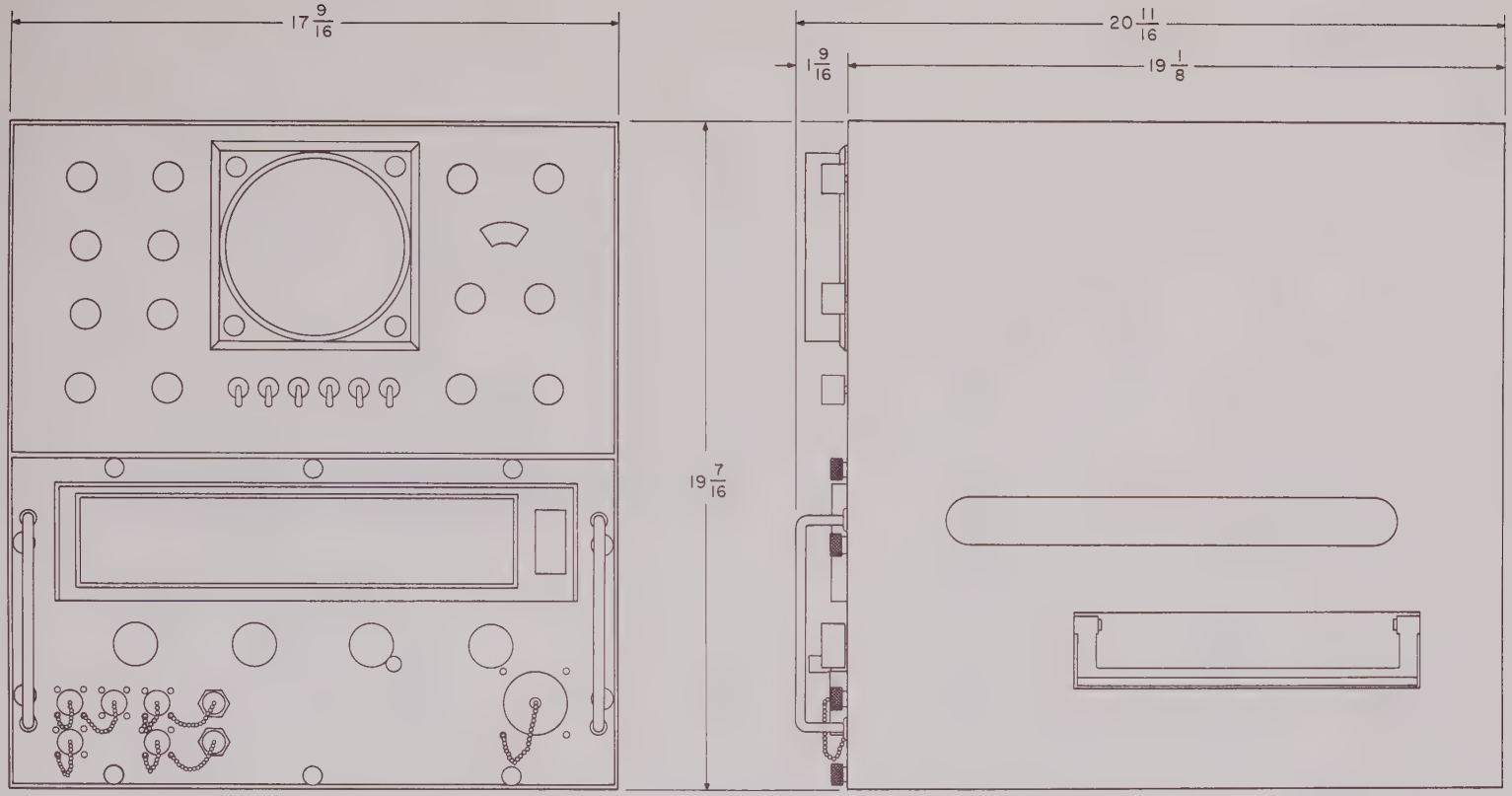

F2 F1 = SWEEP WIDTH
DF = BANDWIDTH



SPA-10 AND SPA-5

FIG. I-II BANDWIDTH VERSUS SWEEPWIDTH WAVE (ARTWORK)

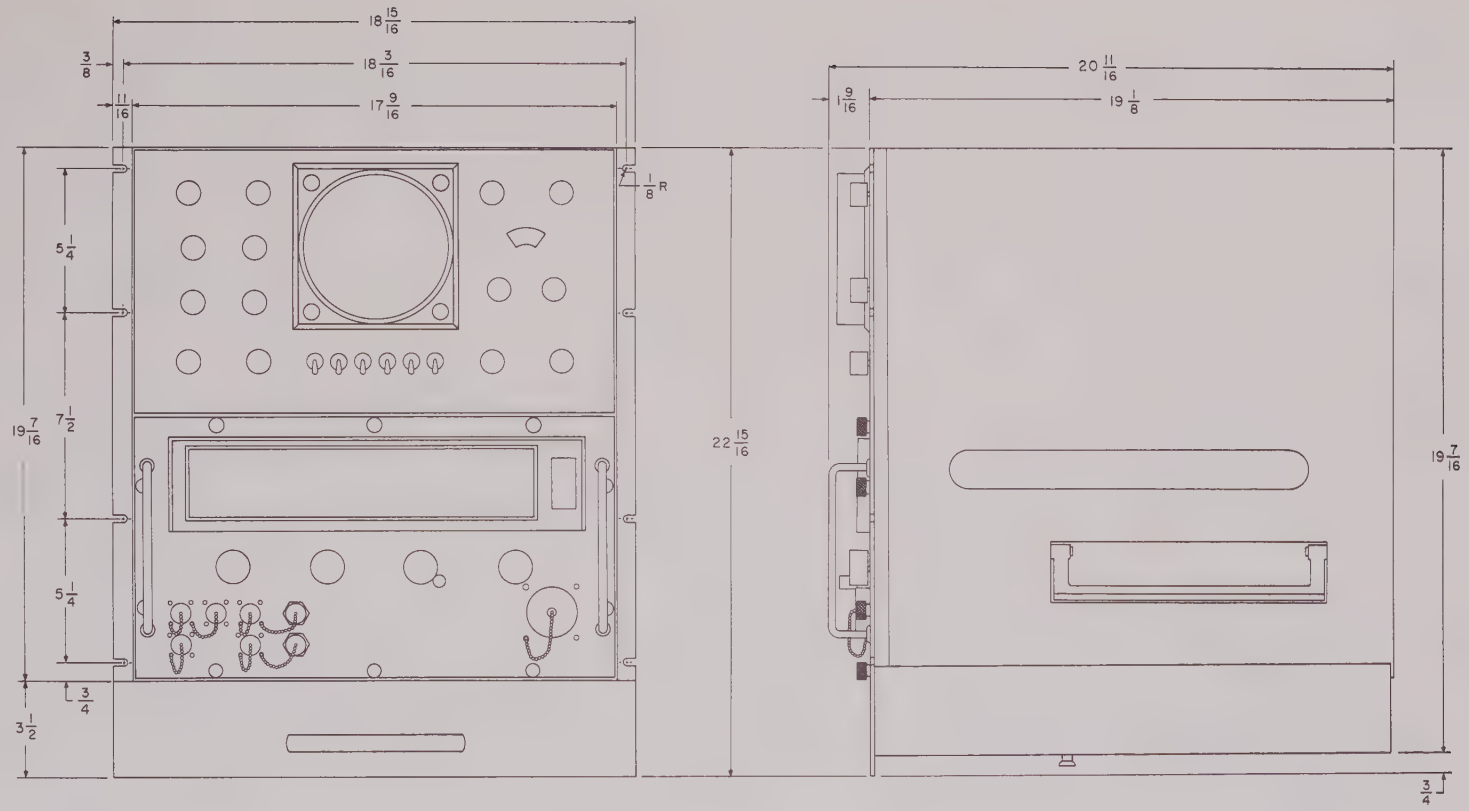
556160-001




A3

Fig. II-1 OUTLINE DIMENSIONAL DRAWING, MODEL SPA-10, IN CABINET

556014-854




A4

Fig. II-2: OUTLINE DIMENSIONAL DRAWING;
MODEL SPA-10, WITH MOUNTING RACK AND TRAY

556014-853

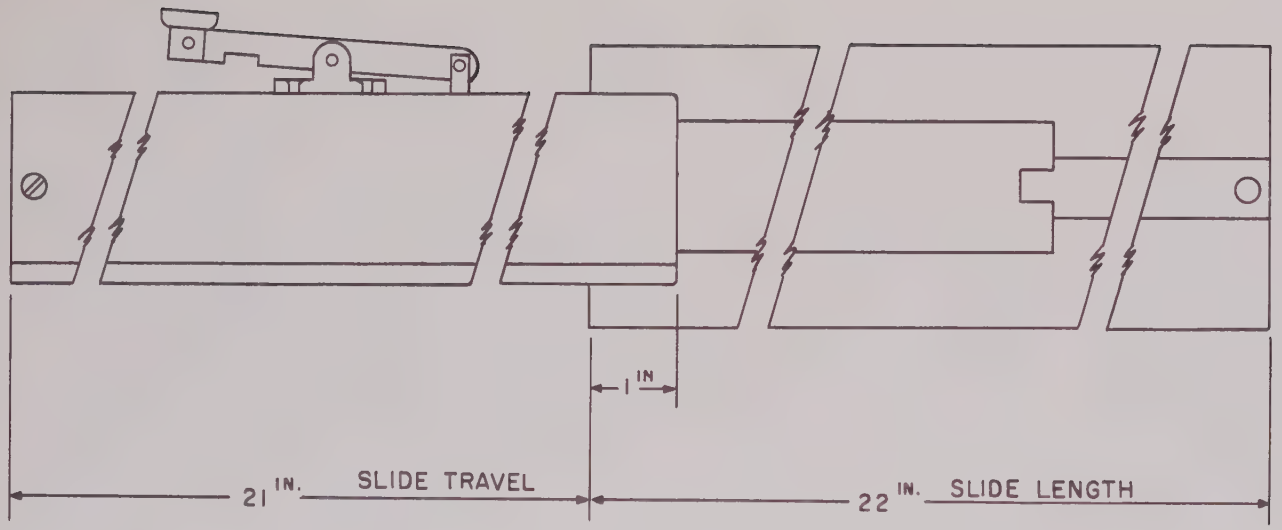





Fig. II-3 : SLIDE, RACKMOUNT

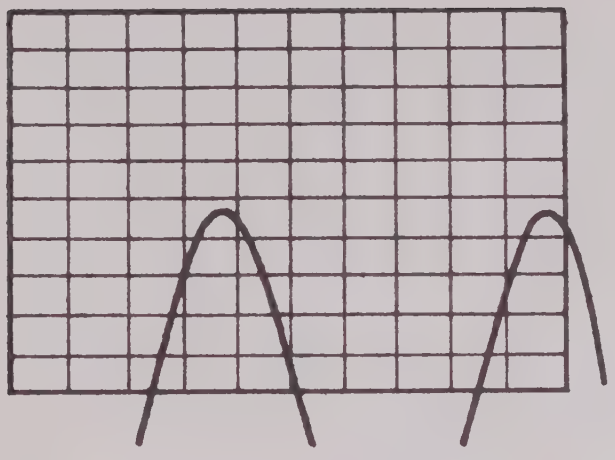


Figure II-4. Screen Presentation for 30 cps Sweep Rate

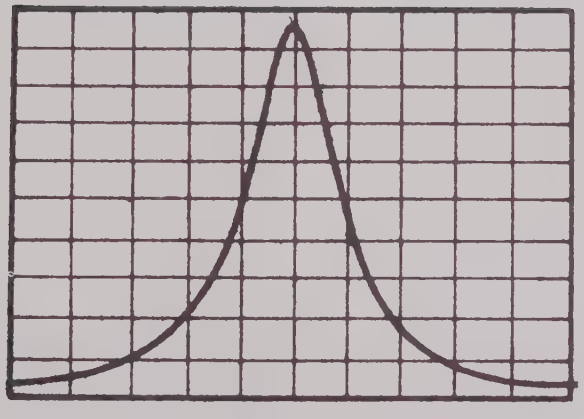


Figure II-5. Expanded Pip Display

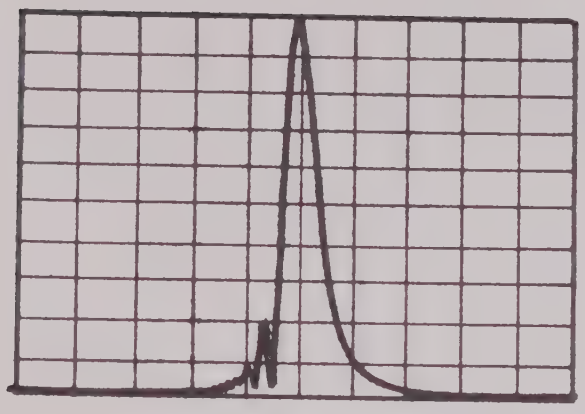
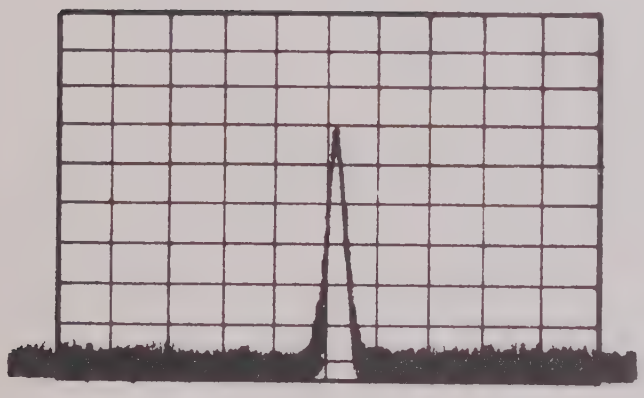
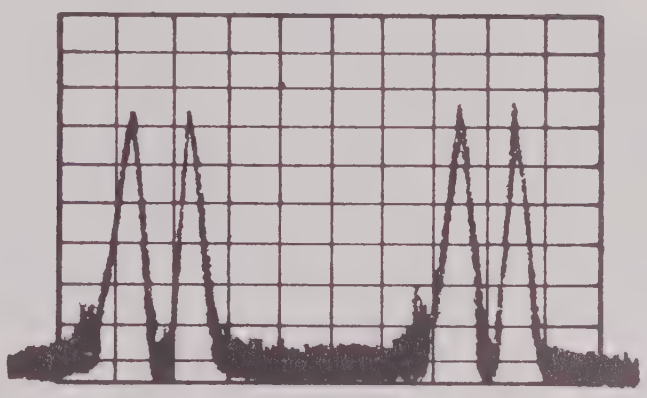


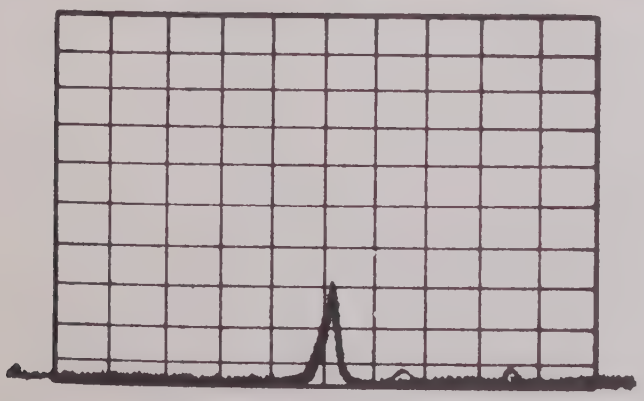
Figure II-6. Optimum Resolution



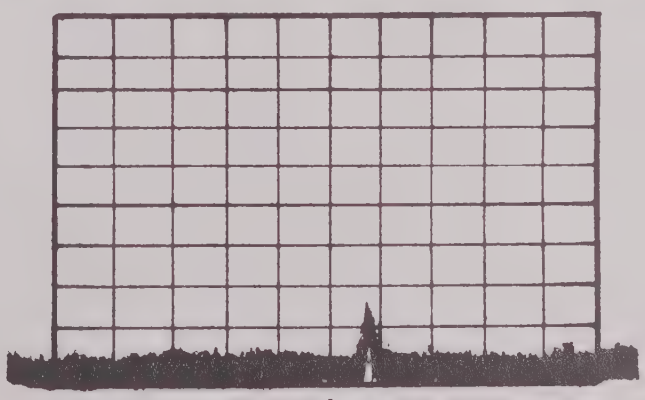
a.



b.

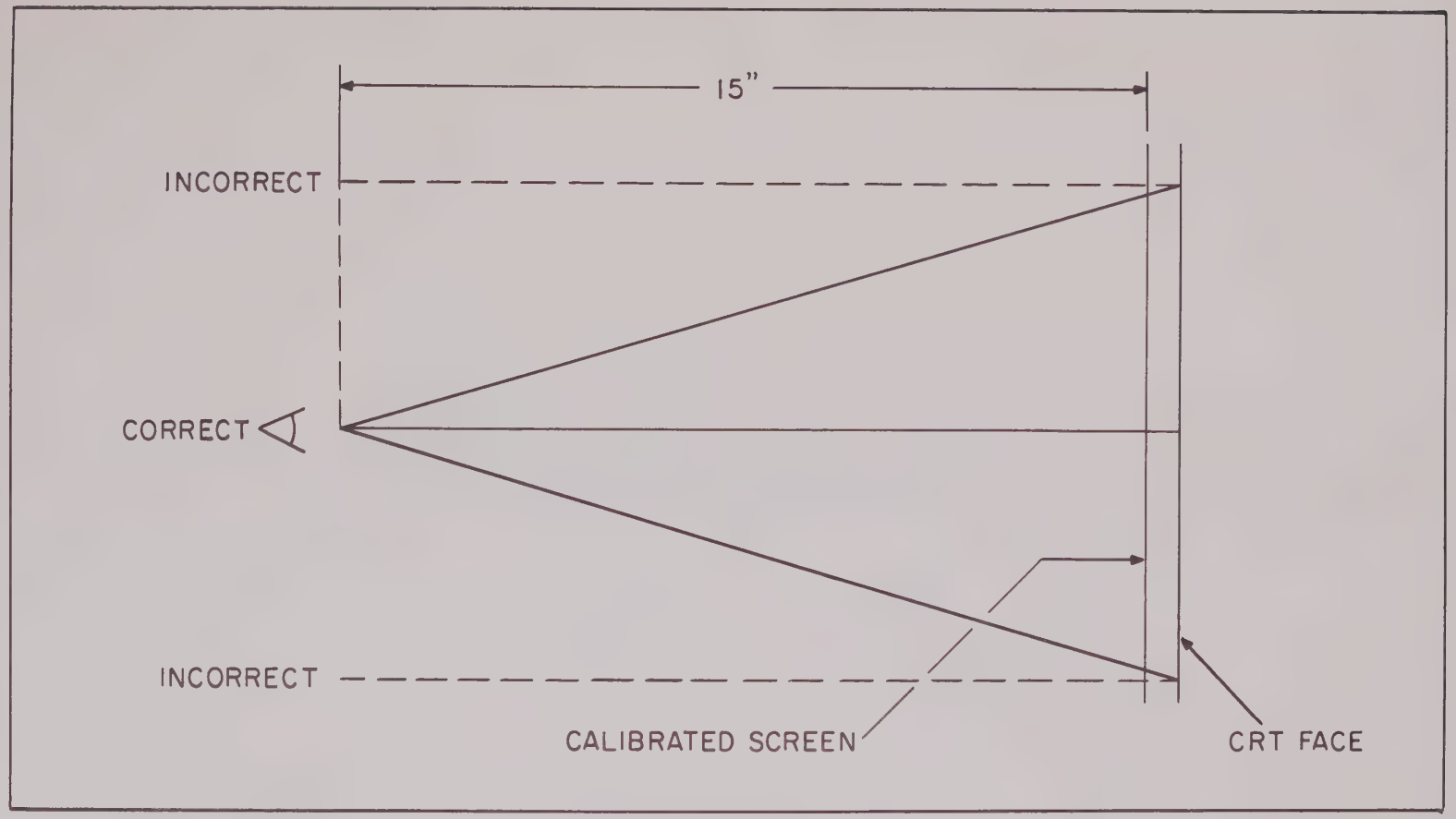


c.



d.

Figure II-7. Sensitivity Measurements




SPA-10 & SPA-5
CORRECT VIEWING OF CRT SCREEN

FIG. III - 1



556014-857

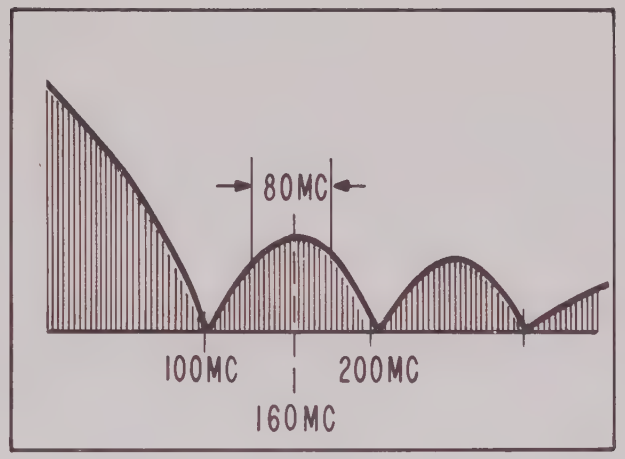



FIG. III - 2



SPA-10 & SPA-5
SPECTRUM OF .01 u sec PULSE

556014-865

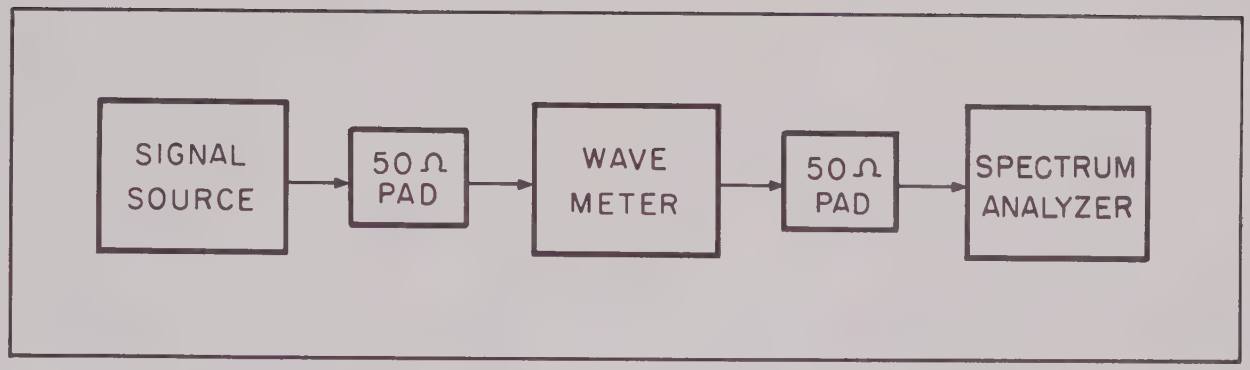



FIG. III - 3

A10

MODEL: SPA-10, SPA-5

TEST SETUP FOR WAVEMETER MEASUREMENTS

556014-861

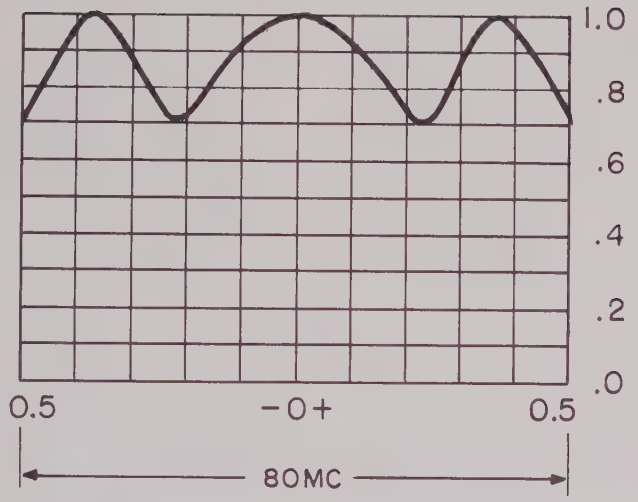
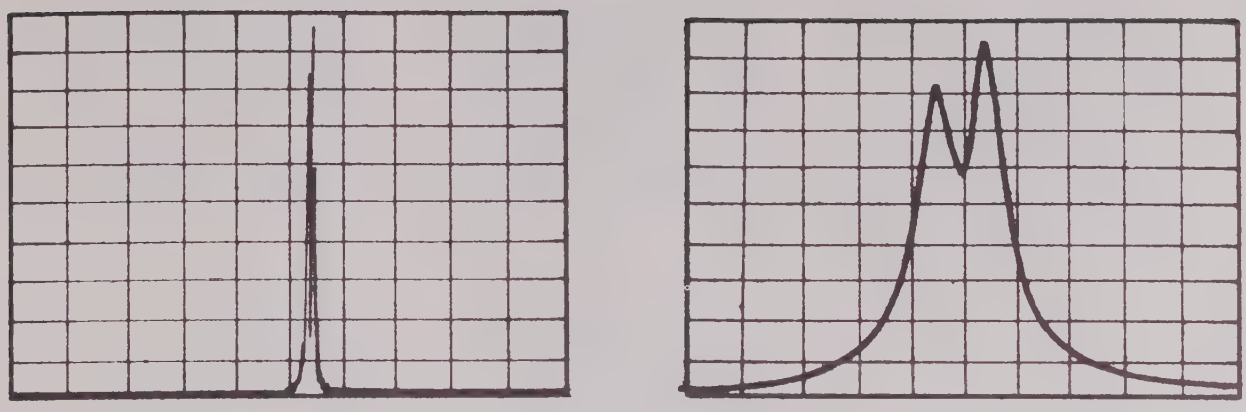



FIG. III - 4

TYPICAL IF FLATNESS CURVE

556014-866



a. Two Interfering Carriers at Maximum Sweep Width

b. Same signals as "a" at Reduced Sweep Width, Resulting in Improved Separation or Resolution

Figure III-5. Resolution of Interfering Signals

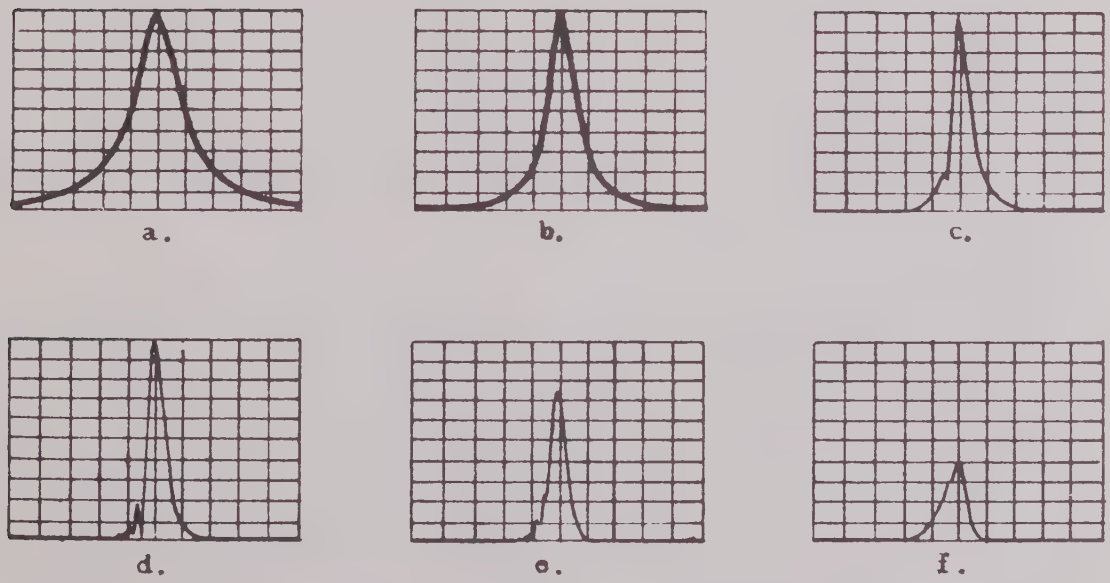


Figure III-6. Ringing as an Indication of Optimum Resolution

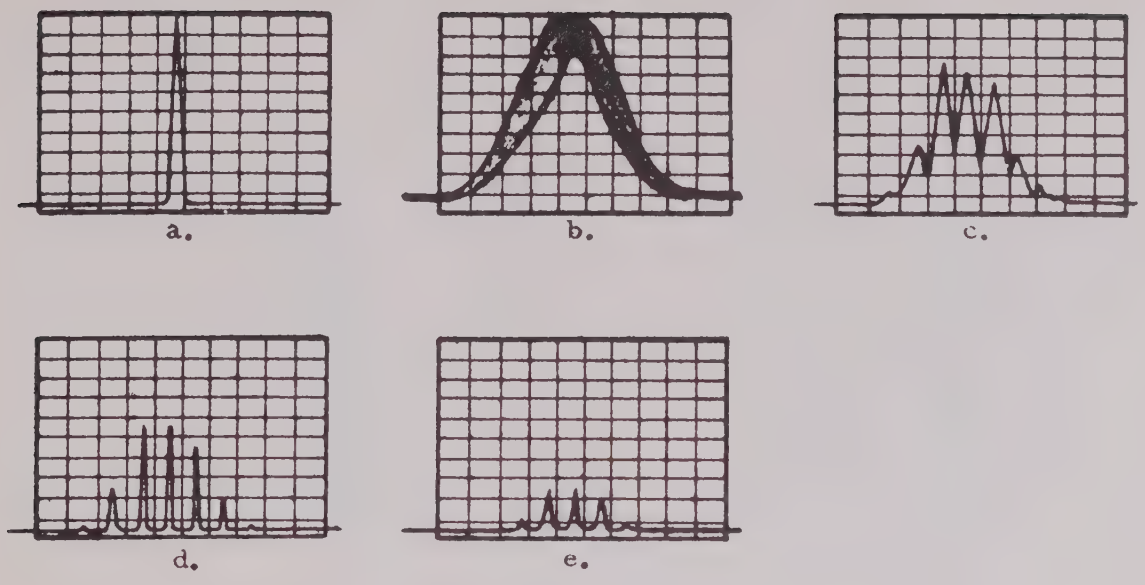



Figure III-7. Separation of Closely Spaced Signals

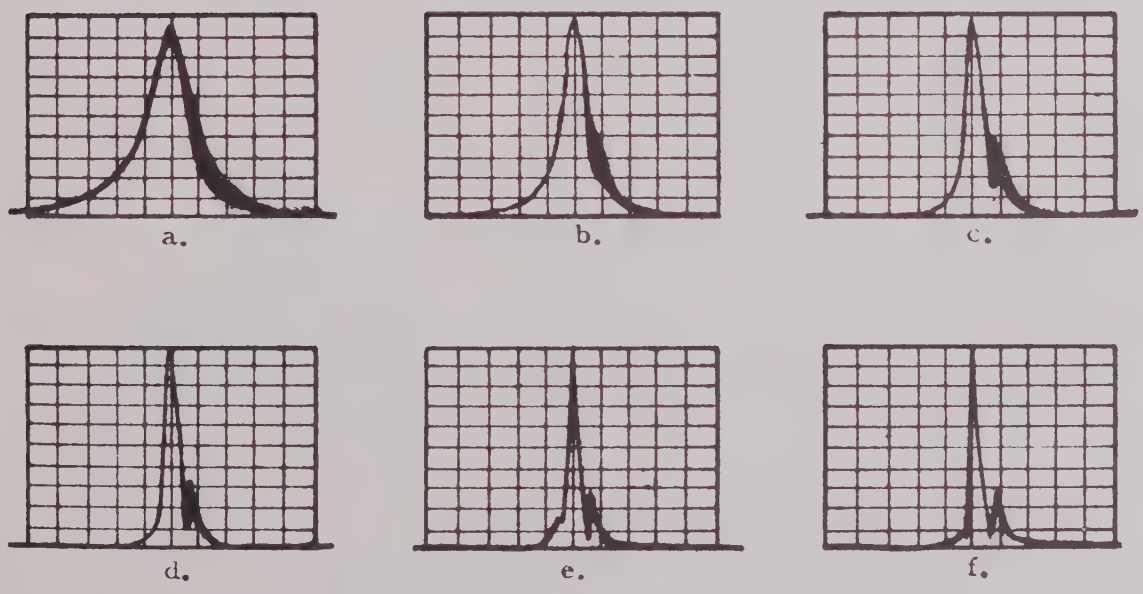
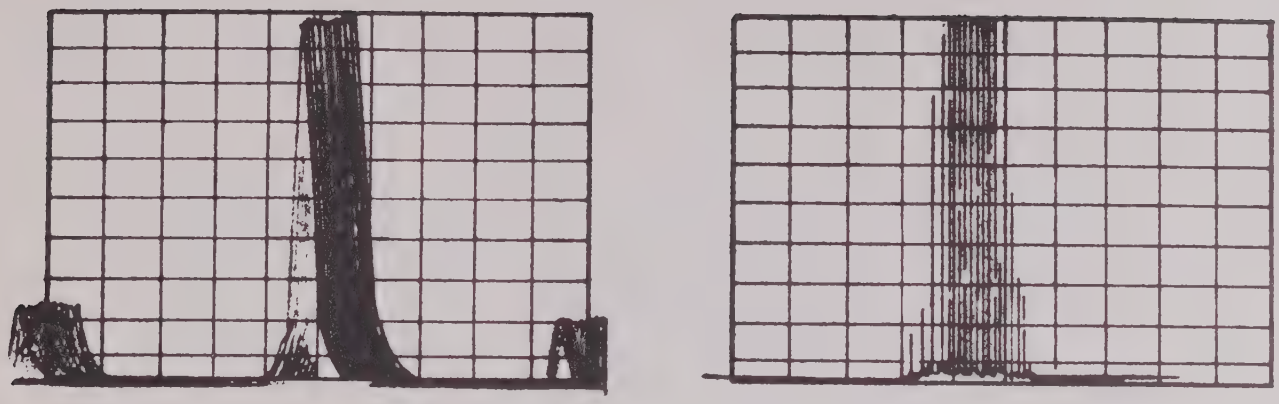
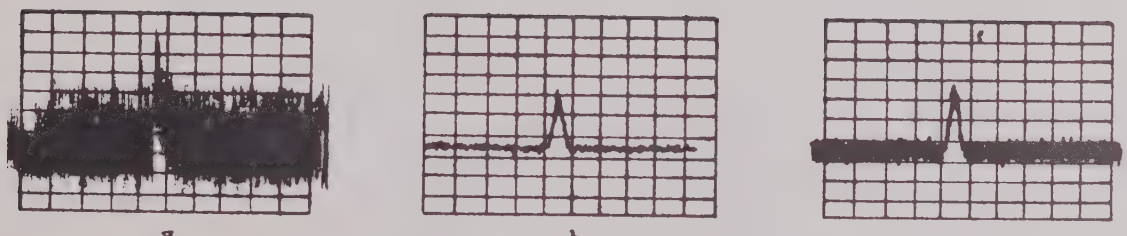



Figure III-8. Resolution of Signals of Unequal Amplitude



a. b.

Figure III-9. Spectrum of Incidental FM



a. b. c.

a. Video Filter Control Counterclockwise

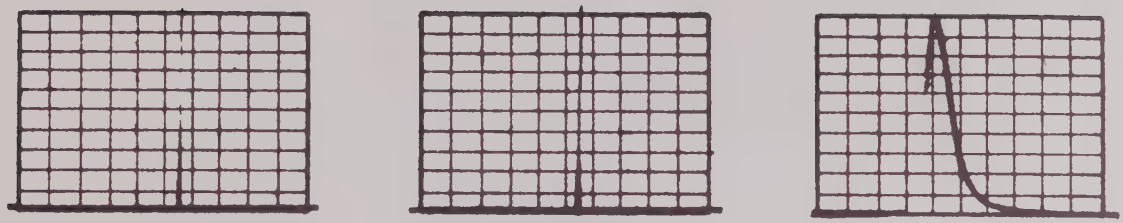
b. Video Filter Control Clockwise

c. Video Filter Control Mid-position

Figure III-10. Video Filter Effects

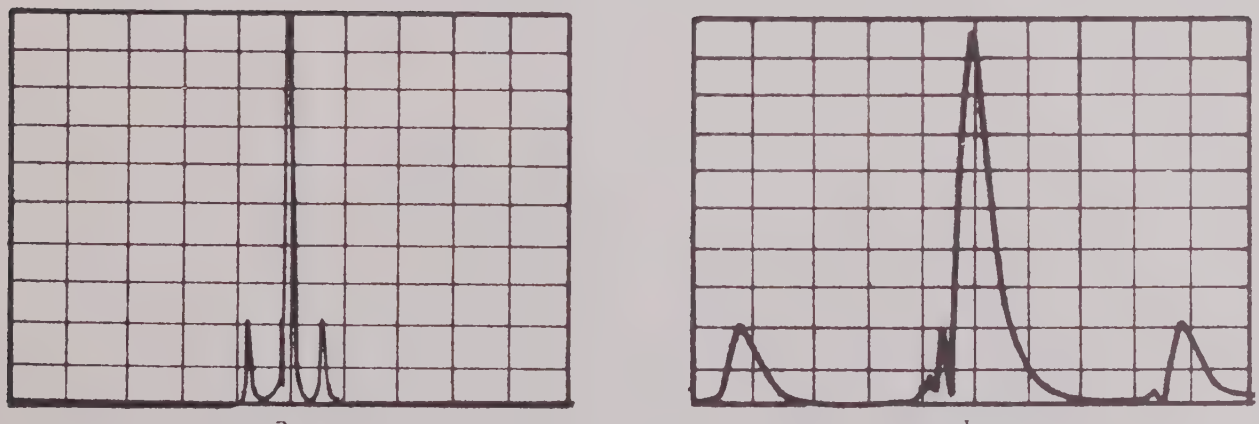


556160—185



a. b. c.

Figure III-11. Correct Use of INTENSIFIER Control



a. b.

a. Amplitude-Modulated Signal Showing Carrier and Two Sidebands

b. Same AM Signals as "a" at Reduced Sweep Width, Carrier Remains at Center of Screen

Figure III-12. Amplitude Modulated Signal

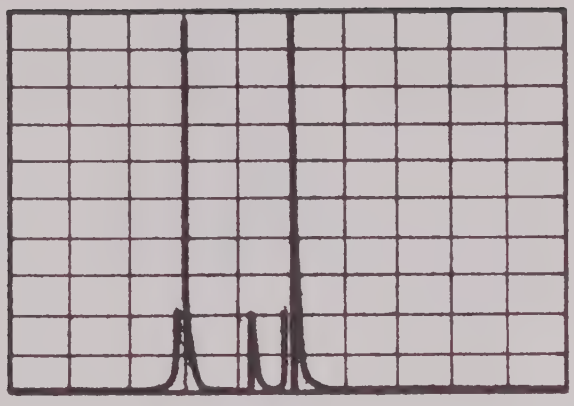
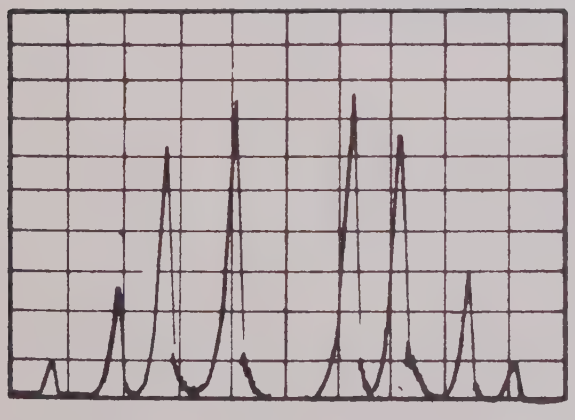
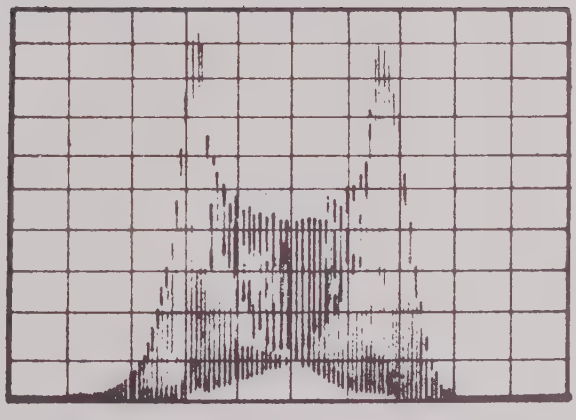


Figure III-13. Spectrum of Balanced Modulation

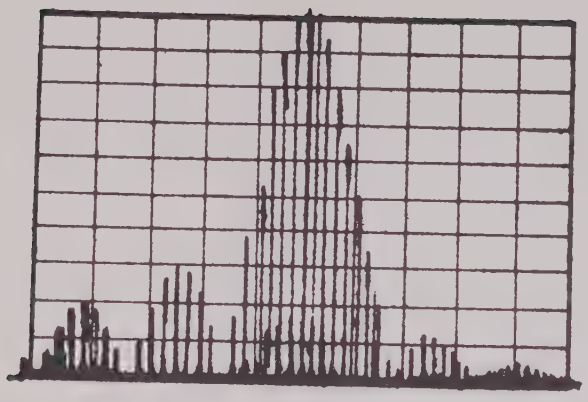


a.

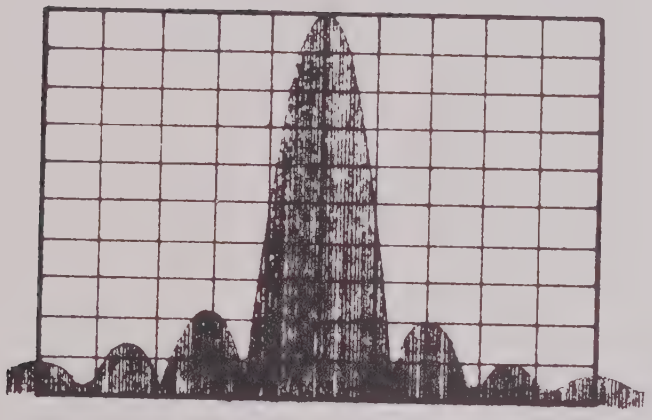


b.

Figure III-14. Spectra of FM Modulated Signals



a.



b.

Figure III-15. Spectrum of Pulse-Modulated Wave Comparing Fast and Slow Sweep Speeds

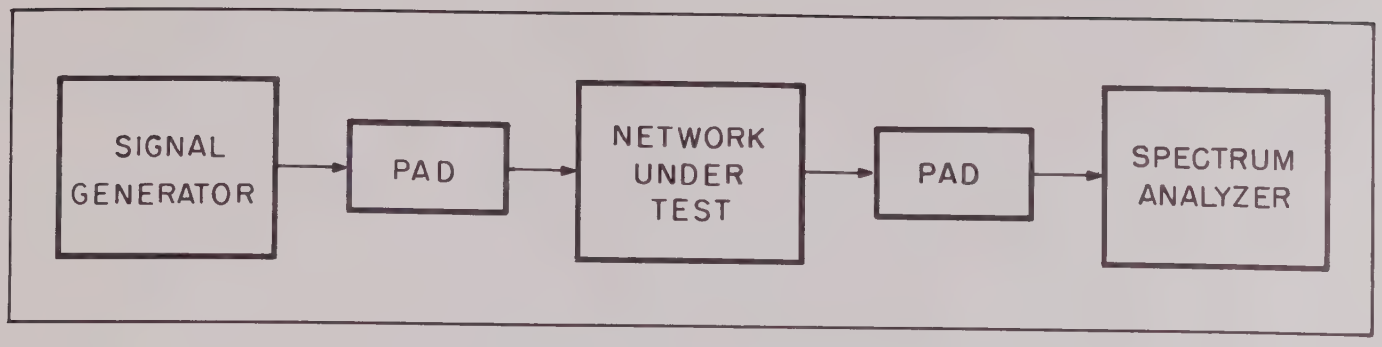



FIG. III - 16 INSERTION LOSS TEST SETUP (A)

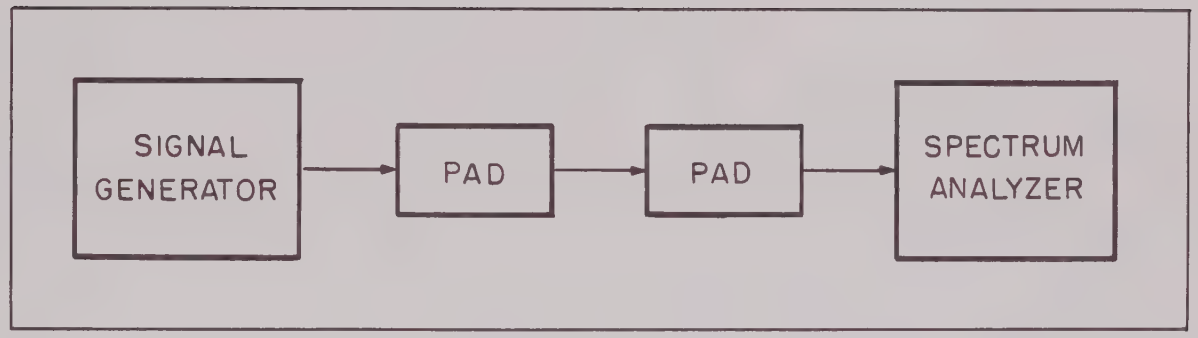
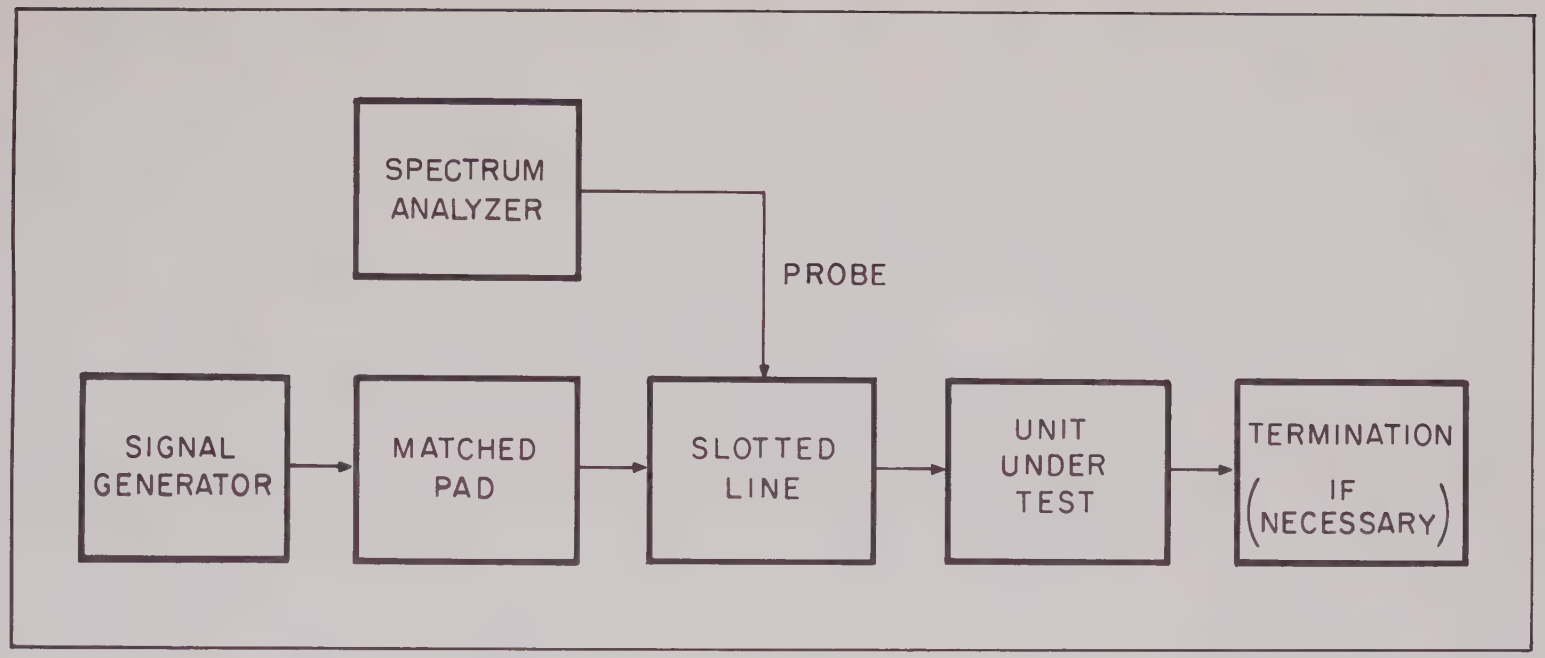



FIG. III - 17 INSERTION LOSS TEST SETUP (B)

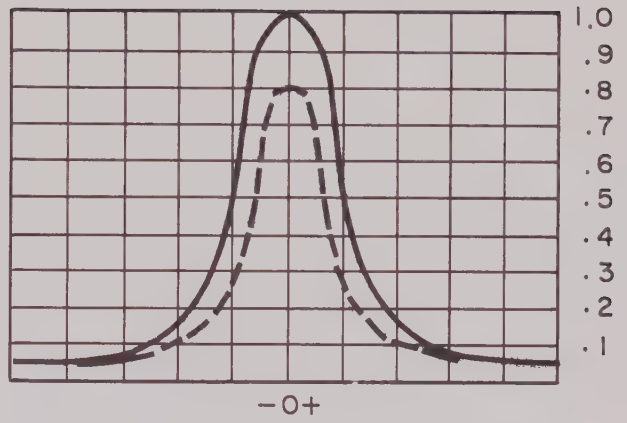



A2 0

FIG. III - 18

MODEL: SPA-10, SPA-5
VSWR TEST SETUP

556014-860




A21

FIG. III - 19

MODEL SPA-10 & SPA-5
VSWR RESPONSE

556014-859

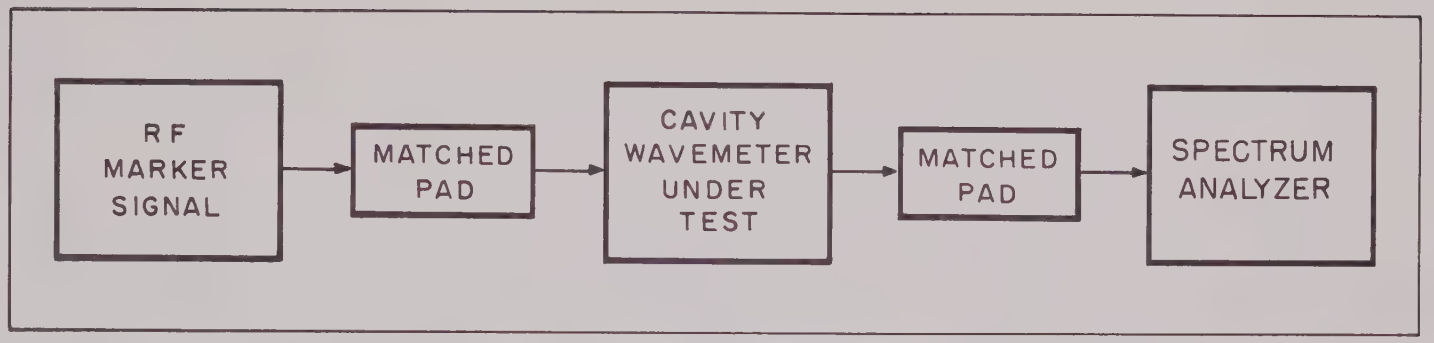



FIG. III - 20

MODEL: SPA-5, SPA-10
TEST SET-UP FOR WAVEMETER CALIBRATION

A22

556014-863

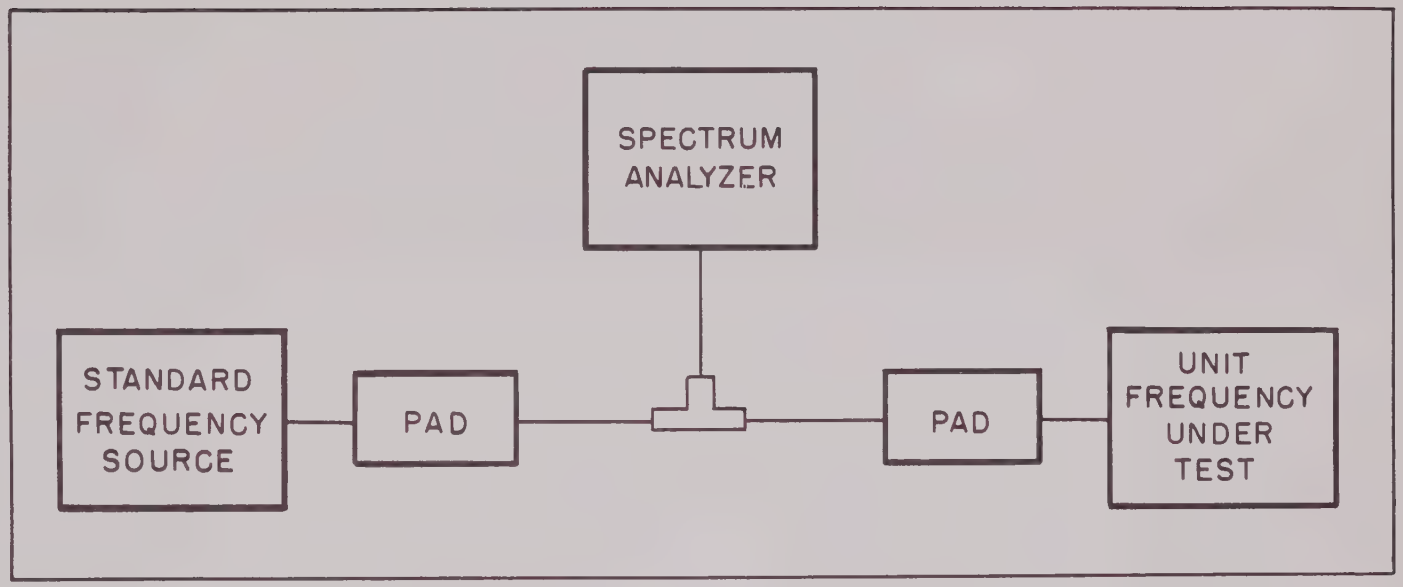



FIG. III-21



SPA-5, SPA-10

VISUAL FREQUENCY COMPARISON TEST SET UP

556014-856

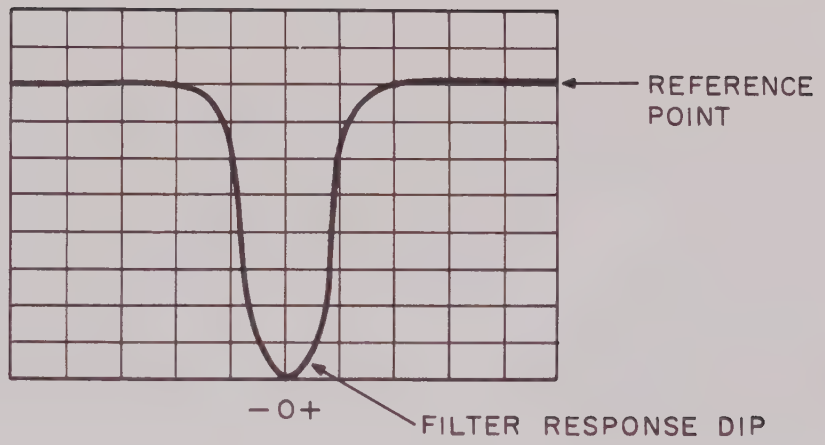





FIG. III - 22

SPA-10 & SPA-5
FILTER RESPONSE

556014-858

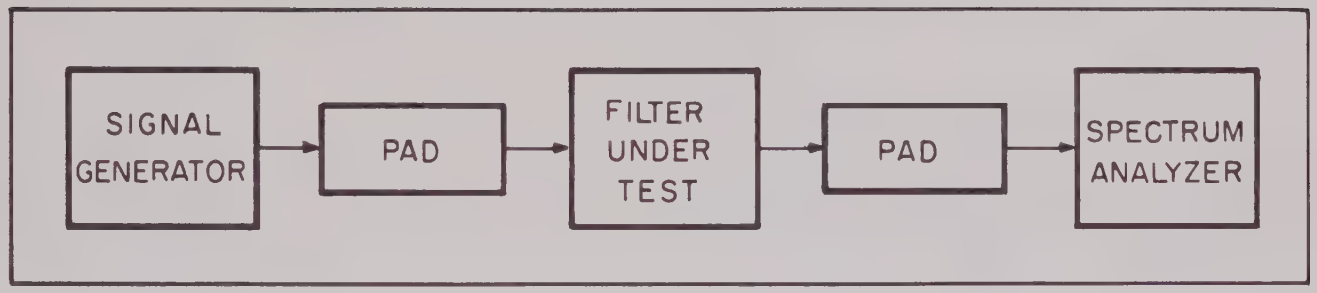





FIG. III - 23

SPA-10, SPA-5
TEST SETUP FOR FILTER RESPONSE

556014-862

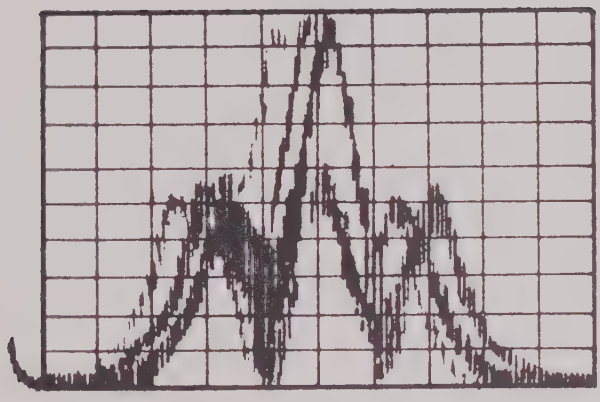
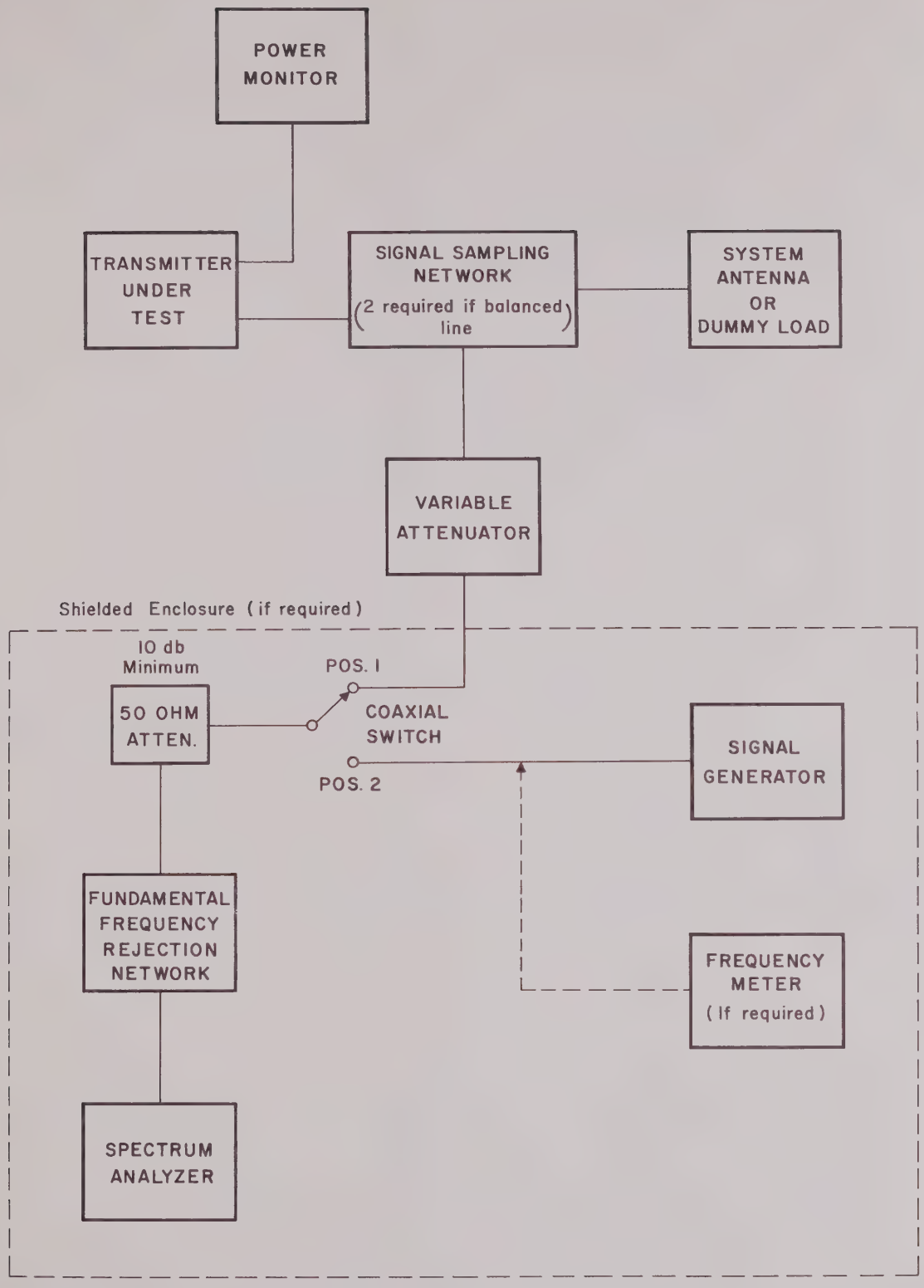


Figure III-24. Screen Presentation Showing Microphonic Effects

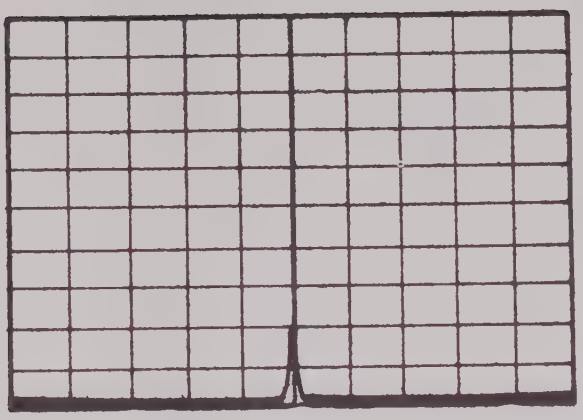




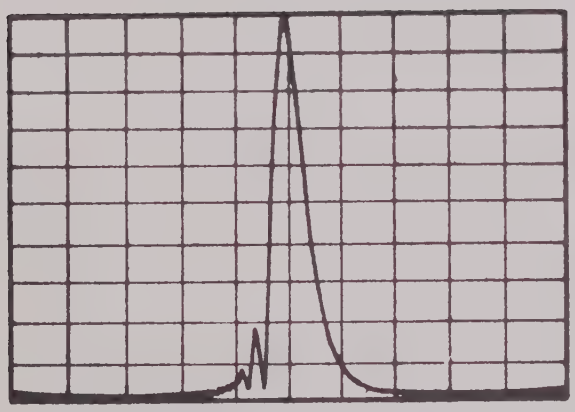

SPA-10 & SPA-5

Fig. III-25: TRANSMITTER OUTPUT MEASUREMENT SET-UP

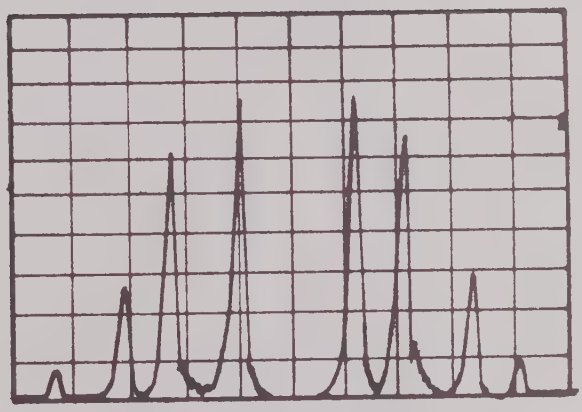
556014-855



a.



b.



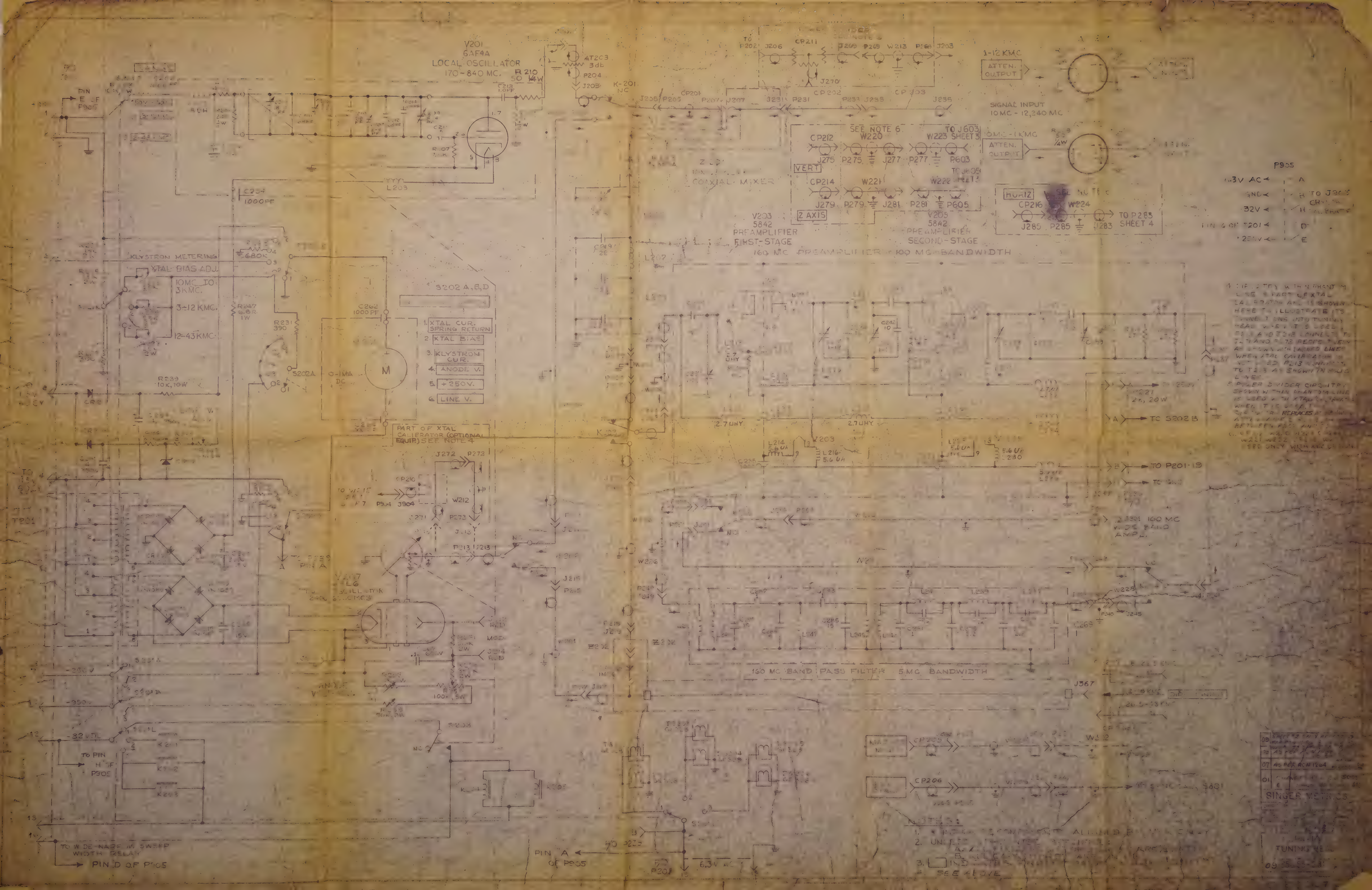
c.

a. Constant Carrier at Maximum Sweep Width

b. Constant Carrier at Reduced Sweep Width

c. Frequency Distribution of an FM Signal

Figure III-26. Typical CRT Indications



V201
6AF4A
LOCAL OSCILLATOR
170-840 MC.
R 210
50 1/4W
C213
1.0PF
AT203
3db
P204
J203
K-201
NC
J206
CP211
J270
CP201
CP202
CP 203
J235
P207
J207
J231
P231
1-12 KMC
ATTEN.
OUTPUT
SIGNAL INPUT
10MC - 12,240 MC
SEE NOTE 6
CP212
W220
J275
P275
J277
P277
W223
P603
TO J603
SHEET 3
10MC-1KMC
ATTEN.
OUTPUT
1/4W
VERT
CP214
W221
J279
P279
J281
P281
W222
P605
Z AXIS
COAXIAL MIXER
V203
5842
PREAMPLIFIER
FIRST-STAGE
V205
5842
PREAMPLIFIER
SECOND-STAGE
160 MC PREAMPLIFIER 100 MC BANDWIDTH
HORIZ
CP216
W224
J285
P285
J283
TO P283
SHEET 4
P905
6.3V AC
GND
32V
A
B
H
D
E
PIN
E OF
P905
RANGE
C204
1000PF
L203
R207
KLYSTRON METERING
XTAL BIAS ADJ.
680K
10MC TO 3KMC.
3-12 KMC.
12-43 KMC.
R247
6.8Ω
1W
R231
390
R239
10K, 10W
CR2
S202A
S202 A,B,D
C262
1000 PF
0-1MA
DC
M
1. XTAL CUR. SPRING RETURN
2. XTAL BIAS
3. KLYSTRON CUR.
4. ANODE V.
5. +250V.
6. LINE V.
PART OF XTAL
CALIBRATOR (OPTIONAL
EQUIP.) SEE NOTE 4
J272
P272
CP210
W212
P904
J904
P273
P213
J213
T201
PIN A
V207
OSCILLATOR
MOD
R215
100K, 5W
ANODE
-350V
-950V
-32VDC
TO PIN
H OF
P905
K201
K202
K203
S203
NC
TO WIDE-NARROW SWEEP
WIDTH RELAY
PIN D OF P905
C219
22
L207
2.7UHY
2.7UHY
L214
5.6UH
L216
5.6UH
C235
C242
10
C259
R221
2K, 20W
TO S202B
TO P201-19
5.6 UH
230
160 MC
WIDE BAND
AMPL.
W226
J215
P215
P249
J249
C285
15
L247
L245
W228
P245
J245
C269
160 MC BAND PASS FILTER 5MC BANDWIDTH
J367
CP205
CP206
W302
PIN A
OF P905
P201
6.3V AC
NOTES:
1. * ... ALIGNED ... ONLY
2. UNLESS OTHERWISE SPECIFIED:
3. IND...
4. SEE ABOVE
09
07 AS PER ACN 1264
01
SINGER METRICS
TUNING HEAD

V301
5842
160 MC AMPLIFIER

V302
5842
160 MC AMPLIFIER

V304
12AX7
AGC AMPLIFIER

V305
6AQ5A
AGC AMPLIFIER

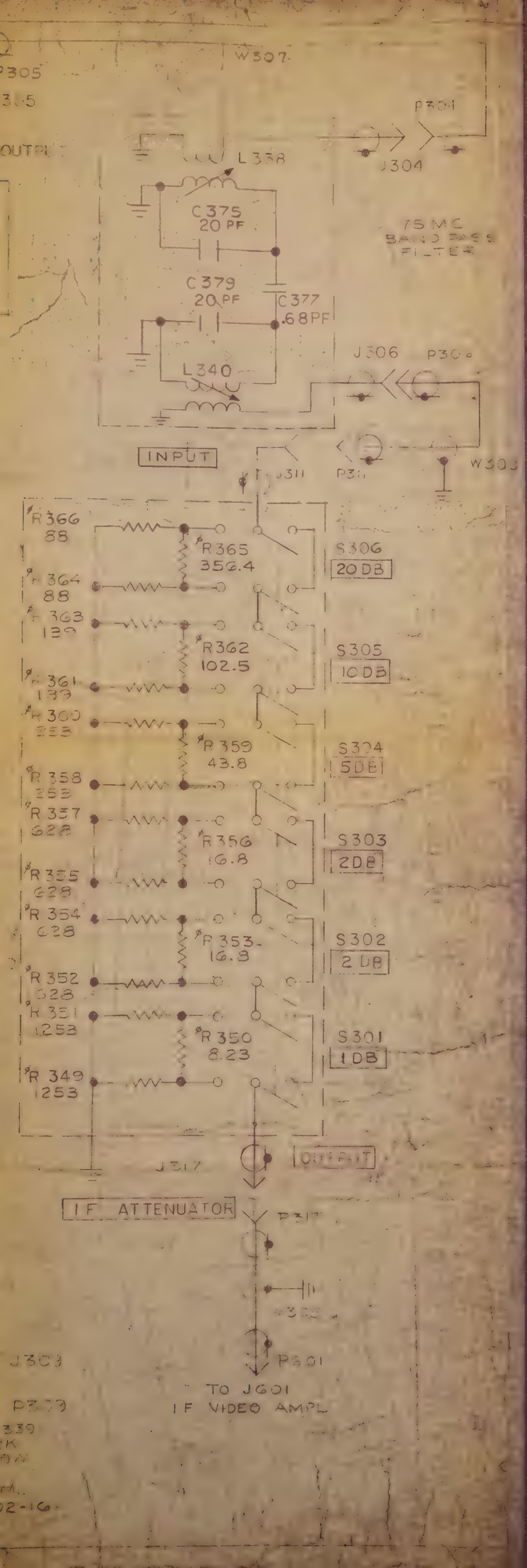
V306
6AQ5A
SAWTOOTH DRIVER

V307
6AF4A
SWEPT
OSCILLATOR
235 ± 35 MC

SCHEMATIC OF MARKER OSC.

SPECTRUM CENTERING

+250V




NOTES:

UNLESS OTHERWISE SPECIFIED

1. ALL FIXED RESISTORS ARE $\frac{1}{2}$ W.
2. ALL CAPACITORS ARE IN UUF.
3. "[ ]" INDICATES FRONT PANEL MARKING.
4. "Ø R" INDICATES 1% RESISTORS.
5. "✳" INDICATES COMPONENTS ARE ALIGNED BY MANUFACTURER ONLY.

½ V603 6J6 MIXER

6BJ6 69.5MC OSCIL

6X8 CATHODE FOLL

6BJ6 6.5MC AMP

6EJ6

L607 2.5 MH

L617 2.5 MH

L613 2.5 MH

2.5 MH

Z601 6.5MC IF

75 MC IN

TO J603

C611 1000PF

C614 .02

62PF

22K

4.3K 1W

4.3K 1W

A623 2K 2W

R624 1K

C623 .02

.56UH

R625

R633 180

C631 .02

C619 .2

R642 1K

L623

C621 .02

C618 .02

2.5MH IF

22PF

33PF

20K

R651 100

.02

9001A

R644 10K

C644 20PF

R677 33K

R678 3.0

R679 510

R680 5.6K

R684 10K

R672 100 2W

C675 270PF

C677 .01

R677 91K

TO P603 SHEET 1 SEE NOTE 5

TO P605 SHEET 1 SEE NOTE 5

J605

J603

1K 1W

L601 .1UH

L602 .1UH

L603 .1UH

L604 .1

.1

.01

NOTES

UNLESS OTHERWISE SPECIFIED

1) RESISTORS ARE IN Ω, K=1000.

2) CAPACITORS ARE IN UF.

3) ▭ INDICATES MARKING ON FRONT PANEL

4) * FACTORY ADJUST.

| FACTORY ADJUST | | |
|---|---|---|
| MOD | VALUE | USED |
| R625 | OPEN OUT | |
| R638 | OPEN OUT | |
| R698 | 10K, 2W | |
| C644 | 20 PF | |

5) C675, C677, J603, J605, R680, R684 USED ONLY WITH XYZ OPTION

| | |
|---|---|
| 08 | SHIFTED ONLY APPLIED FOR NON-STD BUILT |
| 07 | REPLACED P0H1264 |
| 06 | |
| 05 | |

| | |
|---|---|
| 01 | PER CO 5795 |

VIDEO IF

03 5-30-156

SHEET 3 OF 7

SYNC. AMPLIFIER
V801
12AT7

SAWTOOTH GENERATOR
V802
6CB6A

CATHODE FOLLOWER
V803
6AB4

HORIZONTAL AMPLIFIER
V804
12AU7A

+330 V.

S801A
CAL SYNC SEL
EXT
CAL
P261
(LINE)
C
F/O P602
S801B
EXT
CAL
2
LINE

C801
R807 1K
R805 220K
C805 .47 4 V
R813
C807 .01
R809 39K
R811 1MEG
R814 3K
R815 50K 2W
SYNC AMPL

E801 NE-16
C809 .05 1500 V

R810 1.1K 1W
R812 12K
R821 470K
R823 .68K
R825A 1MEG 2W
C811 DIFF
C817 4. 400V
R833 1.5K 1W
R835 1.5K 1W
R827 2.4K
R825B 50K 2W
R831 100K
SWEEP RATE
TO V107, PINS 2,4,7 -150 V.

R837 5MEG 1/2W
R860 4.7MEG
LINE SIZE
R845 2.2MEG
C845 .001
R841
R843 1K 1W
C847 .001
R847 1/2W
R849 1K
R857 100K
R859 3.6K
R855 22K 2W
H POS

V801 V802 V803 V804

TO T-11.2
TERM. 15
TERM. 16

R840 2MEG
P283
TO J283 SHEET 1
SEE NOTE 4

SWEEP WIDTH LIMITS
200 KC. ADJ. HIGH
30 MC. ADJ.
K801
NC
NO
R861 10K 2W
R863A 2MEG 2W
R865 500K 2W
200KC. ADJ. LOW
5MC. ADJ.
2W
2W
2W

P307 SAWTOOTH OUTPUT
P201
16
6
2
3

TO +2500 V. H.V. SUPPLY
P105
J105
P/O P602
V701
5ADP1
D
P
N
E
J
(OR)
C701 .05 3000 V.
R711 1.5MEG
R713 200K
TO T11, 6.3 V.A.C.
TERM. 5
TERM. 6
TO -2500 V.

NOTES
UNLESS OTHERWISE SPECIFIED
1. ALL FIXED RESISTORS ARE 1/2 W
2. ALL CAPACITORS ARE IN UF.
3. [ ] INDICATES FRONT PANEL MARKINGS.
4. R840, P283 USED ONLY WITH X-Y OPTION

| | |
|---|---|
| 09 | SHEET 2 ADDED & REVISED |
| 08 | |
| 07 | SHEET 2 ADDED & REVISED |
| 01 | REVISED |

SEE 1 SCHEMATIC
SWEEP GENERATOR, HORIZONTAL AMPL. & BLANKING CKT.
OD 55015E-281
SHEET 2 OF 7

CRT ASSEMBLY

P102

SCALE ILLUM

6.3V

375 V RMS
375 MADC

CR107

CR105

C101 20 600V

C102 20 600V

R105 120

V103 6550

R115 43 1W

R117 1K

R116 2.2M

DC AMPLIFIER V104 12AX7

REFERENCE TUBE V105 OG3

VOLTAGE REGULATOR

-150 V, 20 MA TO R831 SWEEPRATE

TO V701 PIN 1
CRT FIL.

TO V701 PIN 14

R106

TO J201 PIN 3

NOTES:

2. ALL CAPACITORS IN
3. INDICATES FRON
4. * FACTORY ADJUST COMPONENT

| FACTORY ADJUST COMPONENTS | | |
|---|---|---|
| SYMBOL | NOMINAL VALUE | AS USED |
| R154 | 200 K | |

-350V, 30 MA
TO KLYSTRON CATHODE

TO J201 PIN 10
-950V, 5 MA
TO KLYSTRON REPELLER TRACKING

EDITED 02

DC AMPLIFIER V109 6AH6

V114 6BQ5

P201, PIN 12

CR133

1N1605

TO P309 K
-12V. 450 MA.

TO P309 J 13
TO P602 L

TO P602 H 14

15

TO P309 B 6
TO P201 19
TO P104 2

L104 6.8 M

C64 65 50

R172 1K

J104 P104

6.3 V. TO T102 1G

+250 V

09

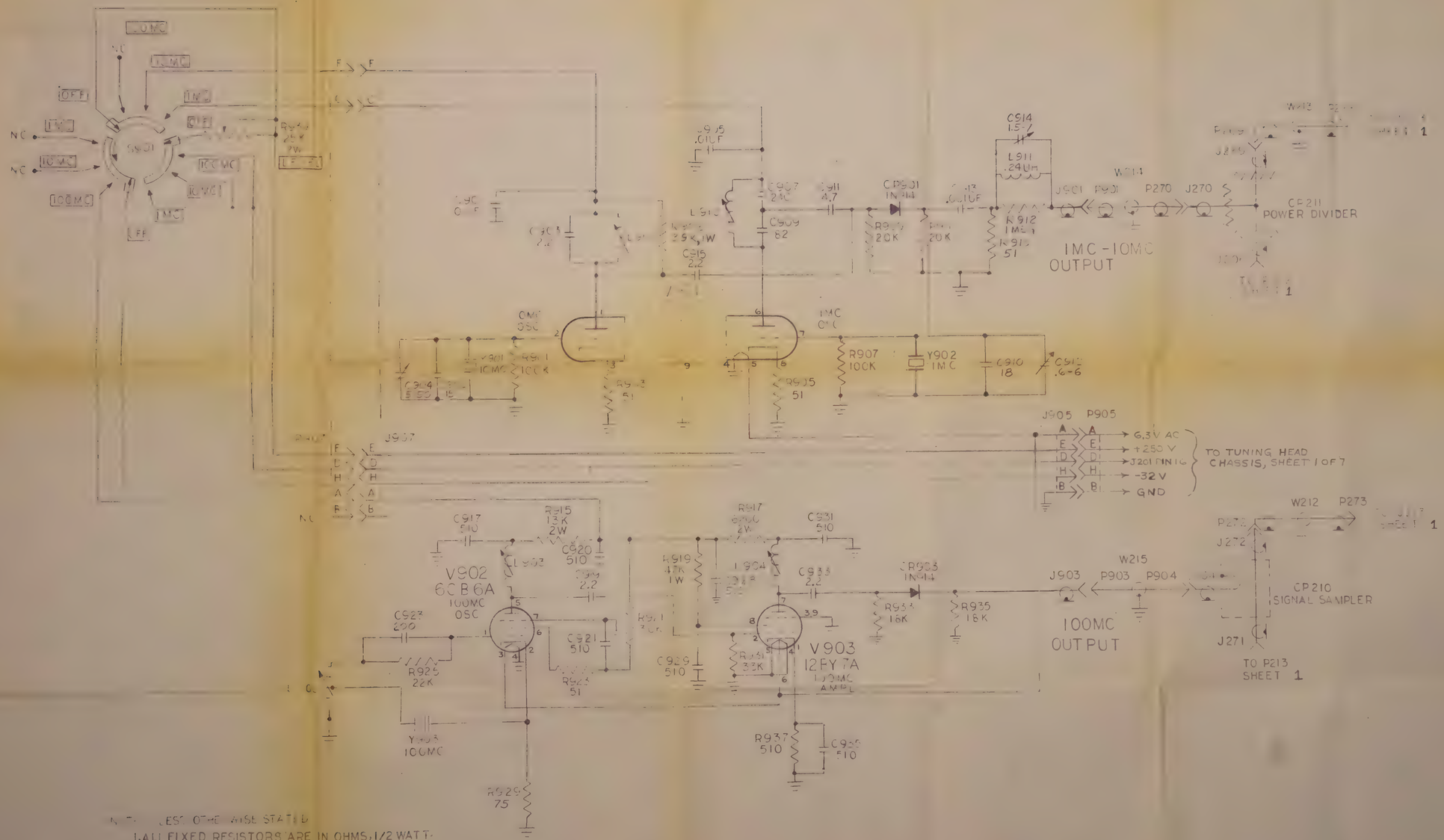
08

07 ADDED PER 1264

0

09 55

SHEET 5 OF 7




NOTE: UNLESS OTHERWISE STATED

1. ALL FIXED RESISTORS ARE IN OHMS, 1/2 WATT.
2. ALL CAPACITORS IN PICOFARADS.
3. SWITCH VIEWED FROM OPPOSITE KNOB END; SWITCH IS IN EXTREME COUNTERCLOCKWISE POSITION.
4. CP211, CP210, W212 & W213 ARE ALSO SHOWN ON SHEET 1.
5. THIS IS AN OPTIONAL PART OF SPA-10.
6. [ ] BOXED IN CHARACTERS APPEAR AS FRONT PANEL MARKINGS.

07 AS PER PCN 1264

CRYSTAL CALIBRATOR SCHEMATIC

SPA-10 USE: ON

09 5C153-281

SHEET 6 OF 7

| REVISIONS | | | |
|---|---|---|---|
| SYM | DESCRIPTION | DATE | APPROVAL |
| | | | |

# SPA-10 SCHEMATIC REVISION & PRINT INDEX

CRYSTAL CALIBRATOR (OPTIONAL EQUIP.)

| REV | ECO NO. | DATE | SHEET 1 | 2 | 3 | 4 | 5 | 6 | DFTSMN | ORDINATOR | SER. NO. | CHANGE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 01 | 5842<br>5855<br>5897<br>5895<br>5878<br>5870<br>5874 | 3-4-63<br>3-13-63 | ✓ | | ✓ | ✓ | ✓ | | HG | MS 1/6<br>MS 3/11<br>MS 1/63 | | PER MARKED UP PRINTS SUBMITTED BY K. PLESSET OF SCHEMETIC CHANGES OF 7/23/63. |
| 02 | 6036 | 10-7-63 | ✓ | | | | | ✓ | HG | MS 1/9/64 | | SEE NOTE 1. |
| 03 | 6164 | 11-30-63 | | | | | | ✓ | HG | MS 12-4-63 | | C927, 51 PF WAS 510 PF |
| 04 | 6312<br>6360 | 2-5-64 | ✓ | | ✓ | ✓ | | ✓ | HG. | MS 2-7-64 | | REVISED PER MARKED UP PRINTS TO INCLUDE XYZ OPTION, XTAL CAL UPDATE |
| 05 | 6386 | | | | ✓ | | | | HG | MS-2-10-64 | | REVISED PER MARKED UP PRINTS 1 PRINT SET. |
| 06 | PCN 1069 | 3/13/64 | | | ✓ | | | | R.W. | MS 3-16-64 | | REVISED PER PCN # 1069 MARKED UP PRINT SUBMITTED |
| 07 | PCN 1264 | 5/6/64 | ✓ | ✓ | ✓ | | ✓ | ✓ | Orndorff | | | REVISED PER PCN # 1264 MARKED UP PRINTS SUBMITTED |
| 08 | PCN 1453 | 8-4-64 | ✓ | ✓ | ✓ | | | ✓ | Vanlue | MS 8/21/64 | | REVISED PER MARKED PRINTS OF PCN 1453 RWL 8-20-64 |
| 09 | PCN 1536 | 8-26-64 | | ✓ | | | | | R Wargo | MS 8/28/64 | | REVISED PER MARKED PRINT SUBMITTED |

NOTE UNLESS OTHERWISE SPECIFIED
1. ADDED OPTIONAL EQUIPMENT, CRYSTAL CALIBRATOR, TO SET. REVISED AND RENUMBERED SCHEMATIC SHEETS TO INCORPORATE CRYSTAL CALIBRATOR SCHEMATIC BY:
   a. CHANGED SHEET 6, REVISION AND PRINT INDEX, TO SHEET 7.
   b. INCORPORATED CRYSTAL CALIBRATOR SCHEMATIC AS SHEET 6.
   c. MODIFIED SHEET 1, TUNING HEAD.

| | | | | | |
|---|---|---|---|---|---|
| | | UNLESS OTHERWISE SPECIFIED | DRAWN | J.E.F. | 2/7/63 |
| | | DIMENSIONS ARE IN INCHES<br>TOLERANCES ON<br>FRACTIONS ±1/32 DECIMALS ±.010 ANGLES ±1/2° | CHECKED | M.W.L. | 3/7/63 |
| | | | DFTG. SUPV. | | |
| | | MATERIAL | PR. ENGR. | I.G. | 3/7/63 |
| | | HEAT TREAT | | | |
| | | | APPROVED FOR ISSUE | | |
| NEXT ASSY. | USED ON | FINISH | DATE | | |
| APPLICATION | | | | | |

SPA-10 SCHEMATIC REVISION & PRINT INDEX

SINGER METRICS DIVISION
THE SINGER MANUFACTURING COMPANY
915 PEMBROKE ST.
BRIDGEPORT 8, CONN.

| SCALE | | CODE | SHEET 7 OF 7 |
|---|---|---|---|
| | | 09 | 556135-281 |